California Stormwater Quality Association®

Dedicated to the Advancement of Stormwater Quality Management, Science and Regulation

The Socioeconomic Value of Urban Stormwater Capture

Prepared by Ceto Consulting for the
California Stormwater Quality Association

February 2024

ADVANCING SUSTAINABLE STORMWATER MANAGEMENT

The California Stormwater Quality Association (CASQA) is a nonprofit corporation that advances sustainable stormwater management protective of California water resources. With well over 2,000 members, CASQA's membership is comprised of a diverse range of stormwater quality management organizations and individuals, including cities, counties, special districts, federal agencies, state agencies, ports, universities and school districts, wastewater agencies, water suppliers, industries, and consulting firms throughout the state. Collectively, CASQA represents over 34 million people in California.

CASQA's *Vision for Sustainable Stormwater Management*[1] (Vision) defines the actions needed to manage stormwater as an essential component of the state's water resources, support human and ecological needs, protect water quality, and enhance and restore California's waterways. There are four guiding principles to achieve this Vision. Like the legs of a chair, each Principle is essential and all four must be in place to support the whole.

Principle #1: Program Implementation: Projects and programs that use stormwater as a resource, protect water quality and beneficial uses, and efficiently minimize pollution are critical for sustainable stormwater management. Stormwater capture and true source control (identifying and mitigating a pollutant at its source) are the primary drivers of these solutions, with effective BMPs providing an important supportive role.

Principle #2: Permits, Regulations, and Legislation: Permits, regulations, and legislation need to focus on effectiveness and desired outcomes to support sustainable stormwater management. Regulatory and legislative actions must align with and support the other components of the Vision – advancing stormwater capture, true source control, and effective BMPs, increasing public education and awareness focused on stormwater as a resource, and securing funding to support these solutions.

Principle #3: Public Education: Public awareness, understanding, and support is essential to sustainable stormwater management. The key shift is viewing stormwater as a resource that must be protected and integrated into overall water resource management.

Principle #4: Funding: Significant financial investment is required to achieve sustainable stormwater management. Stormwater is the most underfunded portion of the water sector and substantial funding is needed to bring these solutions forward.

GOALS AND CONTEXT FOR THIS REPORT

This report, *The Socioeconomic Value of Urban Stormwater Capture,* is an essential step in meeting the goals of Principle 1 and Principle 4 – to advance stormwater capture and to demonstrate the value of investing in this critical infrastructure.

To date, economic valuations related to stormwater capture have focused on the market value of captured water as well as the monetary value of flood control benefits and avoided damages and loss of life. However, urban stormwater capture provides many other benefits to communities which have not been previously estimated.

To advance this critical work and estimate the socioeconomic value of stormwater capture, CASQA partnered with an academic research team at Ceto Consulting, Inc. Led by Dr. Phillip King, Professor Emeritus of Economics at San Francisco State University, Dr. Kikki Patsch, Associate Professor of Environmental Science and Resource Management at California State University Channel Islands, and Sarah Jenkins, a Principle at Ceto and an economist with a focus on land use and regulatory issues, the research team included over four decades of experience in economics, geomorphology, and land use planning.

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[1] https://www.casqa.org/wp-content/uploads/2022/10/final_-_vision_for_sustainable_stormwater_management_-_10-07-2020.pdf

CASQA's role focused on identifying the study goals, providing technical input related to stormwater management, facilitating engagement with CASQA members, identifying potential case studies, and identifying benefits of stormwater capture. The academic research team at Ceto Consulting independently conducted the research. As such, CASQA is providing this preface for greater context (why the work was conducted), with the report developed by Ceto presented independently.

Acknowledgements

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- Dr. Kiki Patsch, Principal Consultant at Ceto Consulting and Associate Professor of Environmental Science and Resource Management at California State University Channel Islands
- Sarah Jenkins, Principal Consultant at Ceto Consulting
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- Joseph Draper, Program Manager, CASQA
- Jim Rasmus, Co-Chair of CASQA's Stormwater Capture and Use Subcommittee and Senior Principal, Pacific Region Stormwater Practice Leader at Stantec
- The many volunteer leaders in CASQA's Stormwater Capture and Use Subcommittee

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Disclaimer

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Executive Summary

The California Stormwater Quality Association (CASQA) contracted Ceto Consulting (Ceto) to analyze and estimate the socioeconomic value of urban stormwater capture. Previous studies estimate the market value of the captured water as well as the monetary value of flood control benefits and avoided damages and loss of life. However, urban stormwater capture provides many other benefits to communities which have not been previously estimated.

To inform the estimate of socioeconomic value, the Ceto team surveyed CASQA's membership in the spring of 2023 to determine the benefits most relevant to California. The survey received 97 completed responses, a summary of which are presented in Figure E1.

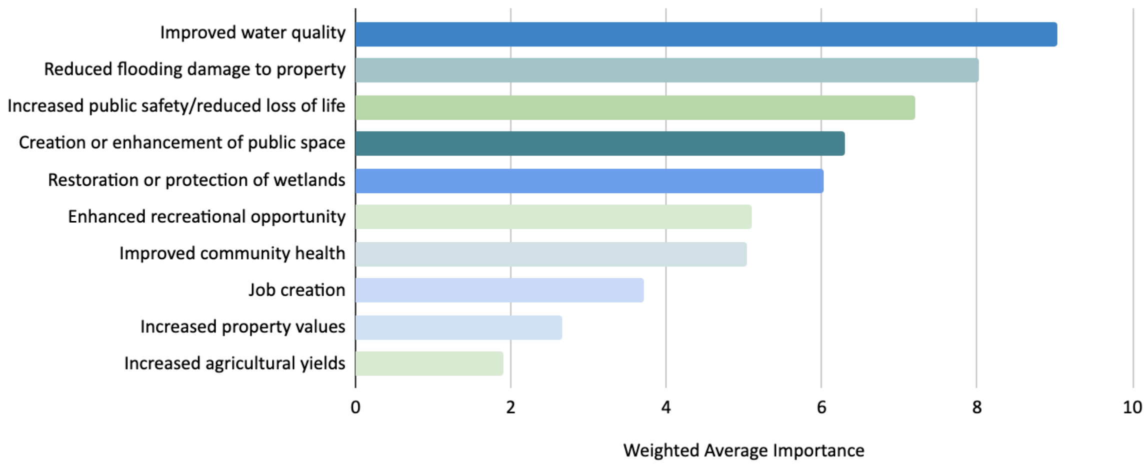


Figure E1: Benefits of urban stormwater capture ranked by CASQA members in a spring 2023 survey.

As Figure E1 indicates, CASQA's membership rated improved water quality as the most important benefit. Flood control and prevention was rated second, followed by public safety, the creation of public "greenspace," the preservation and creation of urban wetlands, enhanced recreational opportunity, and community health benefits. As flood control benefits (reduced property damage and increased public safety) have a readily available monetary value, CASQA and Ceto decided to focus exclusively on the following five non-market benefits: community health, greenspace creation, wetland restoration, recreation, and water quality enhancement.

Drawing on an extensive literature review, Ceto estimated monetary values for these five socioeconomic benefits by selecting four existing urban stormwater capture projects as case studies. The case studies were spread across three of the nine California Regional Water Quality Control Board Regions: Earvin "Magic" Johnson Park (Los Angeles), Orange Memorial Park (South San Francisco), the San Mateo Sustainable Streets Master Plan, and the Fresno Metropolitan Flood Control District's converted retention basins. Ceto estimated benefits based on the surrounding population that benefits from each project, using three geographic boundaries (100 meters, one-half mile, and two miles) based on the literature review. Publicly available project specifications and GIS analysis refined these estimates based on the information available. The results of this analysis are presented in Table E1.

Table E1: The estimated annual value of socioeconomic benefits for four representative urban stormwater capture projects in California.

Benefit	Benefit Considerations	Earvin "Magic" Johnson Park	San Mateo Sustainable Streets Master Plan	Fresno Recreation Basins	Orange Memorial Park
Community Health	Mental Health: ADHD, medical costs, life satisfaction	$4,910,900	N/A	$23,800,000	$2,706,400
	Physical Health: Avoided medical costs, physical activity, Alzheimer's disease	$28,777,500	N/A	$139,400,000	$15,860,000
	Urban Heat Island: Avoided medical costs, avoided ER costs, prevented loss of life	$311,400	$348,800	$1,170,000	$477,500
	Air Quality	$582	$652	$2,200	$892
Water Quality	Improved Quality or "Good" Quality Maintained	$31,479,900	$108,582,000	$82,600,000	$9,850,000
Green Space	Increase in Property Values within 100m	$9,424,000	$24,732,800	$20,120,000	$16,496,000
Wetlands	Ecosystem Services Provided by Urban Wetlands	$12,854,400	N/A	N/A	$1,589,000
Recreation	Value of Recreation to Community within 0.5 mile	$21,600	N/A	$79,100	$11,900
TOTAL ANNUAL VALUE		$87,780,000	$133,664,000	$267,171,000	$46,992,000
TOTAL ANNUAL VALUE PER PROJECT		$87,780,000	$3,260,000	$12,144,000	$46,992,000
TOTAL ANNUAL VALUE ADJUSTING FOR ESJ		$114,998,000	$133,664,000	$316,531,000	$54,929,000
ANNUAL VALUE PER PROJECT ADJUSTING FOR ESJ		$114,998,000	$3,260,000	$14,388,000	$54,929,000

Table E2 compares the stated costs of each project, as provided by the local government and/or the project designs, to the annual socioeconomic benefits generated by each project. As shown in Table E2, all four projects have a one-year Benefit/Cost Ratio greater than one when considering their socioeconomic benefits alone, indicating a one-year return on investment.

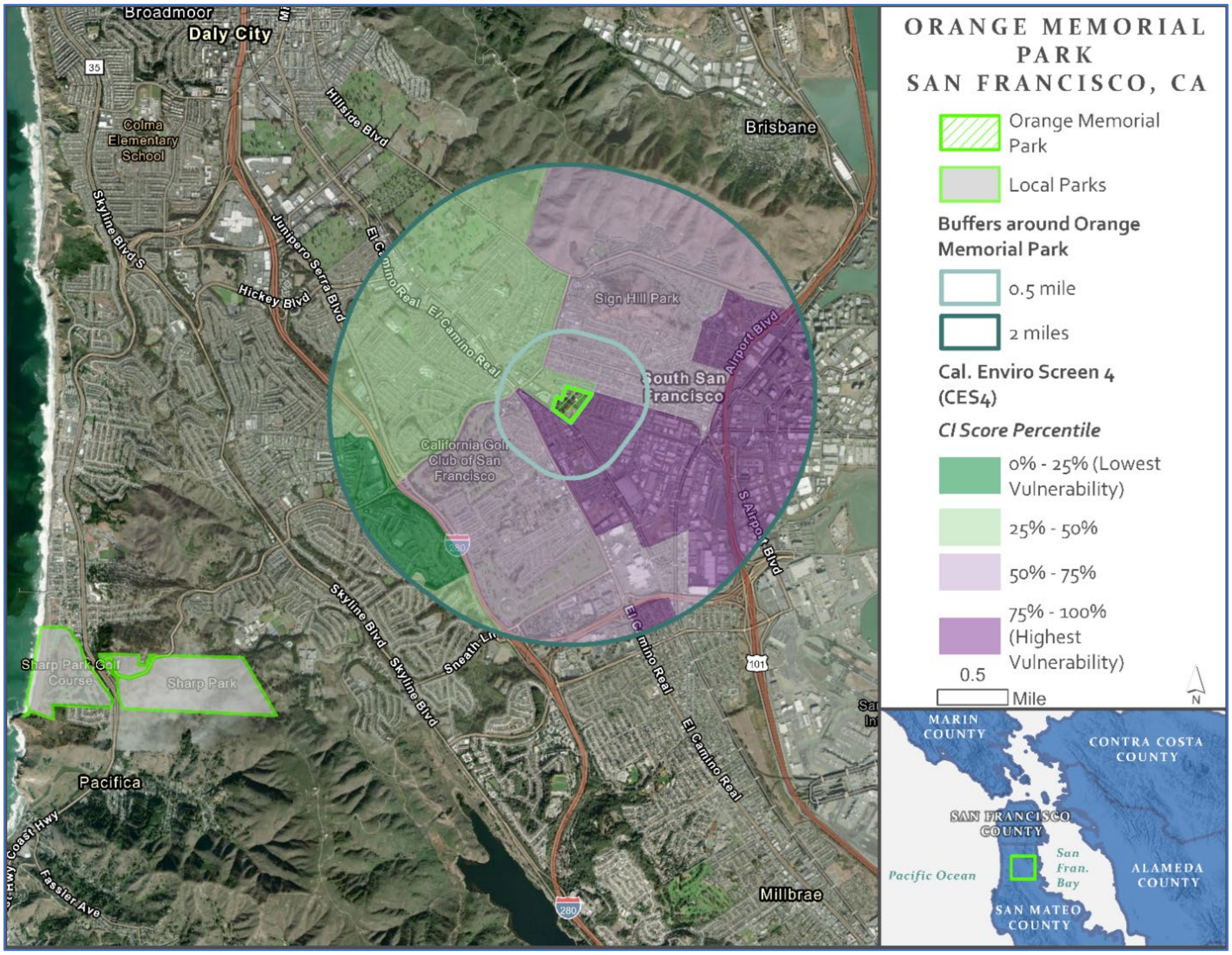
Table E2: Stated costs of each urban stormwater capture project selected as a case study in this analysis, annual socioeconomic benefits, and cost/benefit ratio comparison.

Project	Cost Per Project	Non-Market Value of Socioeconomic Benefits (annually)	Benefit/Cost Ratio
Earvin "Magic" Johnson Park	$83 Million	$88 Million	1.06
San Mateo Sustainable Streets - Average Project	$1.5 Million	$3.2 Million	2.13
Orange Memorial Park	$27.4 Million	$47.0 Million	1.72
Fresno Recreation Basins – Average Project	$5.8 Million	$12.1 Million	2.09

As indicated in Table E2, the *annual* dollar value of the benefits estimated in this report alone exceeded the total cost of the project. In other words, *all* of these projects have a one-year payoff. In a typical benefit/cost analysis, one would examine a multi-year period equal to the life of these projects, such as 20 years. It is highly unusual to find a one-year return. This one-year return indicates underinvestment in urban stormwater capture and that more public investment in this space would likely yield extremely high returns in terms of community benefit.

Orange Memorial Park in South San Francisco represents a particularly good example of the impact of resolving underinvestment in urban stormwater capture, with a one-year rate of return of 1.7 times the initial cost—that implies a return on investment in *months rather than years* (Figure E2). The bulk of the $47 million in benefits generated per year were from urban greenspace and community health, with water quality comprising most of the rest of the benefits. This result indicates that, despite the availability of green spaces within San Mateo County, the City of South San Francisco lacks the type of greenspace that would benefit the community. Also note that this analysis is primarily based on benefits to residents, so employees working in South San Francisco would also likely benefit, adding to the total value of the project.

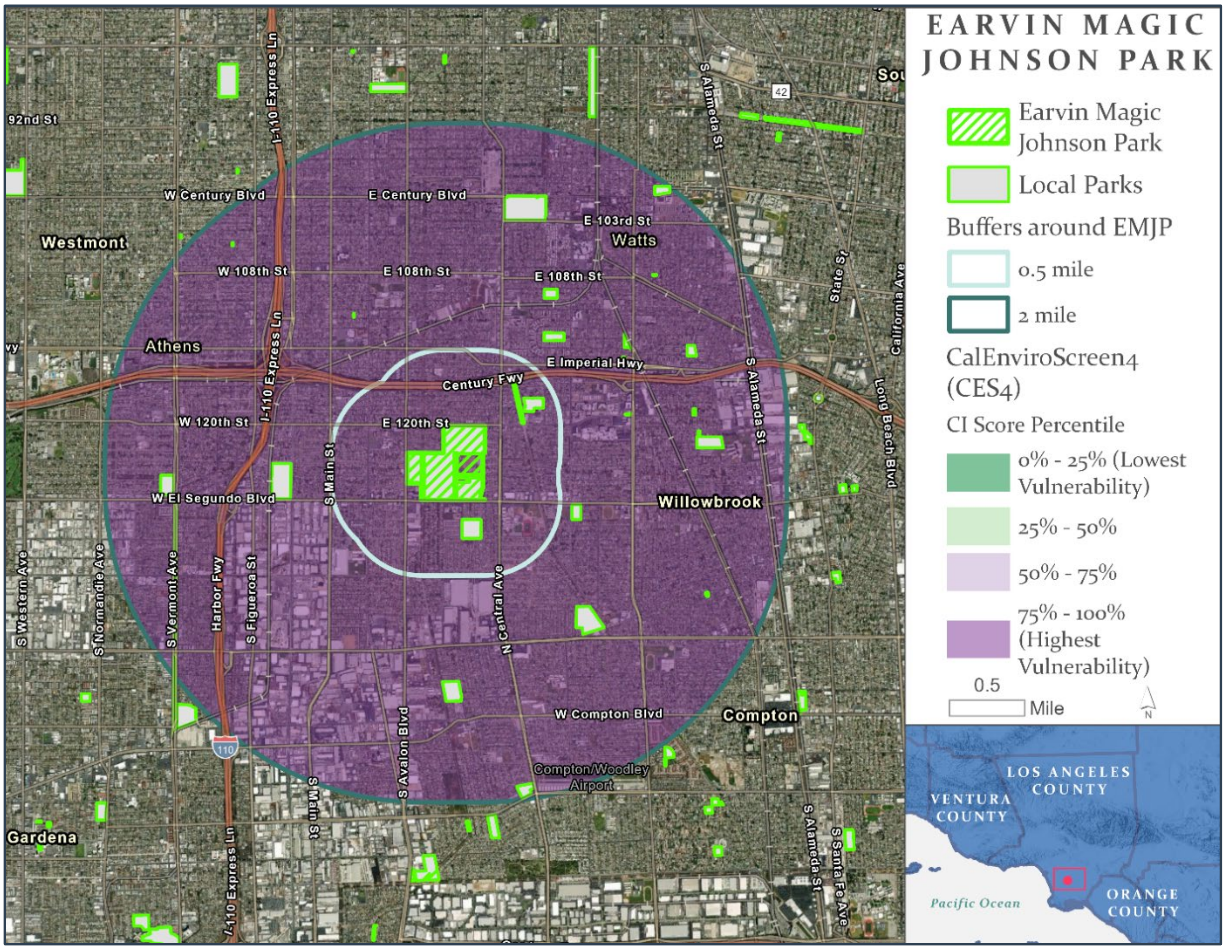
Figure E2: Geospatial analysis of Orange Memorial Park and the surrounding community. The map shows the relatively high vulnerability according to the CalEnviroScreen 4 (purple shading) and the lack of alternate urban greenspace sites.



There is ample evidence that individuals and households in disadvantaged groups are more vulnerable and therefore would receive greater benefits from these types of projects, and the State of California has also prioritized these projects for state funding. If one accounts for underserved populations, as shown in Figure E2, then the results are even more dramatic. Ceto performed an analysis of underserved communities using CalEnviroScreen and estimated that the benefits for Orange Memorial Park increased from $47 to $56 million based on the vulnerability of the community and the lack of usable greenspace in proximity.

A similar story emerges in Earvin “Magic” Johnson Park in Los Angeles (Figure E3). Without accounting for additional benefits to underserved communities, Earvin “Magic” Johnson Park has a one-year return on investment. However, as indicated in Figure E3, Earvin “Magic” Johnson Park is in a heavily underserved part of Los Angeles. Applying an adjustment for the additional benefits to underserved communities yields an estimated 30% higher return, since Earvin “Magic” Johnson Park serves a highly vulnerable community.

Figure E3: Geospatial analysis of Earvin "Magic" Johnson Park shows high climate vulnerability—as indicated by dark purple shading—for the entire community and that Earvin "Magic" Johnson is the largest greenspace site in the area.



Analysis of the Fresno Metropolitan Flood Control District (FMFCD) shows the value of incorporating usable public space into existing stormwater capture infrastructure. By incorporating a public space and recreational component into their retention basins, FMFCD generated substantial additional socioeconomic value, at over $12 million per site, per year ($14 million per year if adjusted for environmental vulnerability). In one year, the recreation basins generate almost twice the value of their total lifetime cost (acquisition, construction, and engineering). The results of this analysis indicate that greater investment in urban stormwater capture will yield significant socioeconomic benefits, *in addition to the benefits of augmenting the water supply and improving flood control.* The four cases studies used in the report all show a one-year return on investment in terms of social benefits. This report also provides policy makers and planners with a potential roadmap for future projects. Parks and urban greenspaces provide a wide variety of benefits including water quality, health, and (for parks) recreation. The results of this report indicated that future investments in stormwater capture should focus on urban areas with significant underserved populations, as well as emphasizing recreation and other amenities that can add value.

1. Project Overview

The California Stormwater Quality Association (CASQA) contracted Ceto Consulting (Ceto) to quantify the socioeconomic value of urban stormwater capture in California so that these values can be included in the development of future stormwater capture projects in California. Often, these types of benefits are left out of cost/benefit analyses for infrastructure projects, due to their lack of explicit monetary value. Ceto's evaluation of urban stormwater capture focuses exclusively on the non-market value of project design elements that create socioeconomic benefits, focusing on the ancillary impacts that positively affect the surrounding communities but are often outside of the goals of flood management and improved water supply.

This project builds on an extensive literature review of the benefits of urban stormwater capture, leveraging peer-reviewed and government-backed estimates of the value of these various benefits. The analysis also incorporates a survey of CASQA members about the potential socioeconomic benefits of stormwater capture, in order to focus the estimates on the most salient benefits for California residents. In addition, Ceto used geospatial analysis to apply peer-reviewed estimates to the selected socioeconomic benefits.

In addition to the estimates provided, this report outlines the factors significant at the statewide level, the assumptions made, and the values applied, such that the methodology may be refined and applied at the local or project scale. The analysis also includes discussion of the types of benefits to evaluate, factors that determine the associated values, and regional variances throughout California to consider when applying this methodology to future projects and planning. Finally, the report provides recommendations on maximizing the socioeconomic benefits of stormwater capture projects.

This assessment is among the first of its kind monetizing the socioeconomic benefits of stormwater capture, which are important and often overlooked. Comparing the one-year value of these socioeconomic benefits to the costs of four representative urban stormwater capture projects demonstrates that adding in these benefits significantly increases the total benefits that one can expect from a stormwater capture project and allows one to examine a project more holistically. Previous studies of the socioeconomic benefits of stormwater capture have focused on potential benefits without valuation, or on the specific benefits of an individual project (Cooley et al., 2019; Diringer et al., 2020; The Nature Conservancy & AECOM, 2021; U.S. Environmental Protection Agency (EPA), 2022; Wilson & Xiao, 2023; Wolf et al., 2015). This analysis, in contrast, examines a selection of several stormwater capture projects in California, including both innovative and more traditional projects, and uses these estimates to calculate the value of increased stormwater capture in urban areas throughout the state. In addition, applying environmental and demographic data, this report identifies areas where projects would have the most significant impact.

2. Estimating the Socioeconomic Benefits of Urban Stormwater Capture in California

There are many potential benefits of stormwater capture. Diringer et al. (2020) examined water supply yield, flood damage reduction, water quality, energy or electrical savings, community recreation, public use, property values, habitat value, carbon equivalents, and avoided costs resulting from stormwater capture projects. The United States Environmental Protection Agency (EPA) provides the following benefits of stormwater capture: erosion reduction, reduced nuisance flooding, reduced water pollution, reduced water demand, reduced energy demand, improved habitat, improved air quality, improved stream flows, reduced greenhouse gas emissions, reduced urban heat island effect, prevented or reduce localized flooding, recreational opportunities, improved mental and physical health, and increased property values (Environmental Finance Center, 2019; EPA, 2021). Many of these benefits, including reduced flooding and property damage, improved public safety, and water captured for reuse, can be easily measured, and monetized—there is an explicit cost related to property damage and emergency expenses and a market price for water. Other benefits of stormwater capture, however, are much harder to quantify. In particular, the *socioeconomic* benefits or urban stormwater capture, such as enhanced water quality, recreational space, and public health impacts, are difficult to measure. Furthermore, they lack an associated market price. As a result, these "non-market" benefits are typically not considered in the cost-benefit analysis for stormwater capture projects. To estimate the value of the socioeconomic benefits—in *addition* to the readily quantifiable value of stormwater capture projects—this analysis first determined the most relevant benefits. Monetary values for each of the five selected benefits were derived from existing literature. A dollar-value in 2023 dollars (adjusted using the consumer price index) and a unit was determined for each benefit from the body of literature, as shown in Table 1 below. To demonstrate the significant value of non-market benefits, the standardized estimates were then applied to the design specifications of four urban stormwater capture projects throughout California. For a full list of the literature used, see Section 4 of this report.

Table 1: Breakdown of the socioeconomic benefits assessed in this report and their estimated value from the literature review.

Benefit	Benefit Considerations	Estimated Value (2023 $)	Unit
Community Health	Mental Health: ADHD, Medical Costs, Life Satisfaction	$225/person	0.5-mile population
	Physical Health: Avoided medical costs, physical activity, Alzheimer's disease	$1,300/person	0.5-mile population
	Urban Heat Island: Avoided medical costs, avoided ER costs, prevented loss of life	$1,000/tree	Number of trees in project design
	Air Quality	$2/tree	Number of trees in project design
Water Quality	Improved Quality or "Good" Quality Maintained	$155/person	2-mile population
Green Space	Increase in Property Values within 100m	+ 4% property value	Total property value within 100m of project
Wetlands	Ecosystem Services Provided by Urban Wetlands	$106,500/acre	Acres
Recreation	Value of recreation to community within 0.5 mile	$3.50/person	0.5-mile population

While the four case studies analyzed in this report are not complete cost-benefit analyses of the projects, they compare the estimated annual (one-year) value of socioeconomic benefits generated by each project to the stated costs of each project. This analysis uses the best available information on each project, largely relying on publicly available information. Certain values used in this report—such as the number of trees, for example—are estimates made using project documentation and geospatial analysis. A full cost-benefit analysis incorporating socioeconomic benefits could be made more precise by collaborating with project designers and community planners in the feasibility phase. Further refining these estimates would not significantly alter the benefit-cost ratio for each project.

2.1 Determining Relevant Socioeconomic Benefits - Survey of CASQA Members

The literature on stormwater capture provided an extensive list of benefits. To determine the most relevant socioeconomic benefits to California, Ceto created a survey for CASQA members. This survey included ranking the potential benefits to determine the most salient and asking members to indicate the most common stormwater capture methodologies for their region.

2.1.1 Survey Development

In the spring of 2023, Ceto surveyed CASQA's membership to better understand the use of stormwater capture technologies in California and the relative importance of the potential benefits of stormwater capture to CASQA's members. Ceto compiled a 24-question survey using the online tool SurveyMonkey. To inform the development of the survey questions and answer choices, Ceto reviewed current academic literature and federal guidance on stormwater capture and its benefits (Beugin et al., 2023; C/CAG of San Mateo County, 2021; Choi et al., 2021; Cooley et al., 2019; Diringer et al., 2020; Environmental Finance Center, 2019; EPA, 2021; FEMA, 2022; Fresno Metropolitan Flood Control District, 2023c; Wolf, 2020). Beginning with the benefits discussed in these resources, Ceto grouped the benefits to avoid confusion and double-counting and refined the options to focus on socioeconomic benefits which can be estimated based on existing literature, but which lack market prices (non-market benefits). Benefits with ambiguous valuation were omitted from the survey options. CASQA staff and Ceto met throughout the survey development process to refine the questions and answer options. For example, CASQA staff provided input on the types of stormwater capture methods to be included as answer options based on their expertise of local systems.

2.1.2 Survey Results

Ceto received 97 responses to the survey, including responses from all nine California Water Board Regions (see Table 2). The highest number of responses, for those who identified with a specific region, came from the more densely populated regions of southern California (Los Angeles and San Diego). Seventy-seven percent (77%) of the respondents identified themselves as staff from Municipal Separate Stormwater Systems (MS4s), and 23% of respondents identified themselves as other members of the stormwater management industry. Of the MS4 staff, respondents represented both Phase I (52%) and Phase II (20%) MS4s.

Table 2: Responses to the survey question, "Which regional water board issues your permit?" Results demonstrate that Ceto received responses from all nine regions in California.

Region	Respondents
Region 1: North Coast	6
Region 2: San Francisco Bay	10
Region 3: Central Coast	4
Region 4: Los Angeles	16
Region 5: Central Valley	10
Region 6: Lahontan	3
Region 7: Colorado River	5
Region 8: Santa Ana	10
Region 9: San Diego	14
State Water Board	5
Multiple	8
None of the above	6
Total Respondents	**97**

Five important takeaways were derived from an analysis of the survey results:

1. The most important non-market, socioeconomic benefits of stormwater capture to CASQA members.
2. A ranking of which stormwater capture methods were thought to generate the most benefits.
3. The stormwater capture methods most used by CASQA member communities.
4. Regional differences within California in terms of the importance of stormwater capture benefits.
5. The importance of incorporating environmental and social justice considerations into an analysis of benefits.

Most Important Socioeconomic Benefits

Respondents were asked to rank benefits according to their perceived importance, the results of which are summarized in Figure 1. The following key takeaways are evident from a review of this data:

- Sixty percent (60%) of respondents ranked *improved water quality* as the most important benefit, with an additional 21% ranking it as the second most important benefit.
- Most respondents ranked *reduced flooding damage* in the top 4 (82% of respondents ranked it as 4th or above).
- While some respondents ranked *public safety* most important (7%) or second most important (15%), 33% of respondents ranked it 3rd most important.
- Responses showed more variability in the relative importance of the other benefits (*creation of public space*, *enhanced recreational opportunities*, *improved community health*, and *increased agricultural yields*).
- Respondents collectively ranked *increased property values*, *increased agricultural yields*, and *job creation* as the least important benefits of stormwater capture.

Table 3: Respondents ranked the relative benefits of stormwater capture (see also Figure 1). The "score" for these benefits (right hand column) is a weighted average of their relative importance out of a maximum score of 10.

Benefit	Weighted Score
Improved Water Quality	9
Reduced flooding damage to property	8
Increased public safety/reduced loss of life	7
Creation of public space	6.3
Restoration or protection of wetlands	6
Enhanced recreational opportunity	5
Improved community health	5
Job creation	3
Increased property values	2.6
Agricultural yield	2

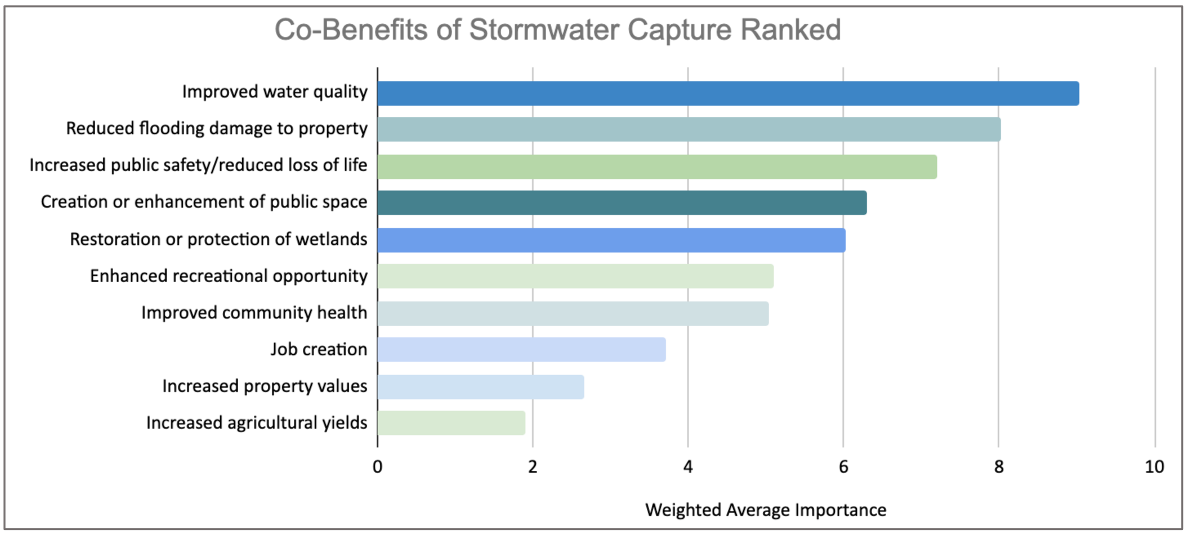


Figure 1: The distribution of responses to the question on the relative importance of benefits of stormwater capture. The "score" for these benefits is a weighted average of their relative importance out of a maximum score of 10. The results indicate that the five most important benefits were: (1) *improved water quality*, (2) *reduced flooding damage to property*, (3) *increased public safety/reduced loss of life*, (4) *creation or enhancement of public space*, and (5) *restoration or protection of wetlands*.

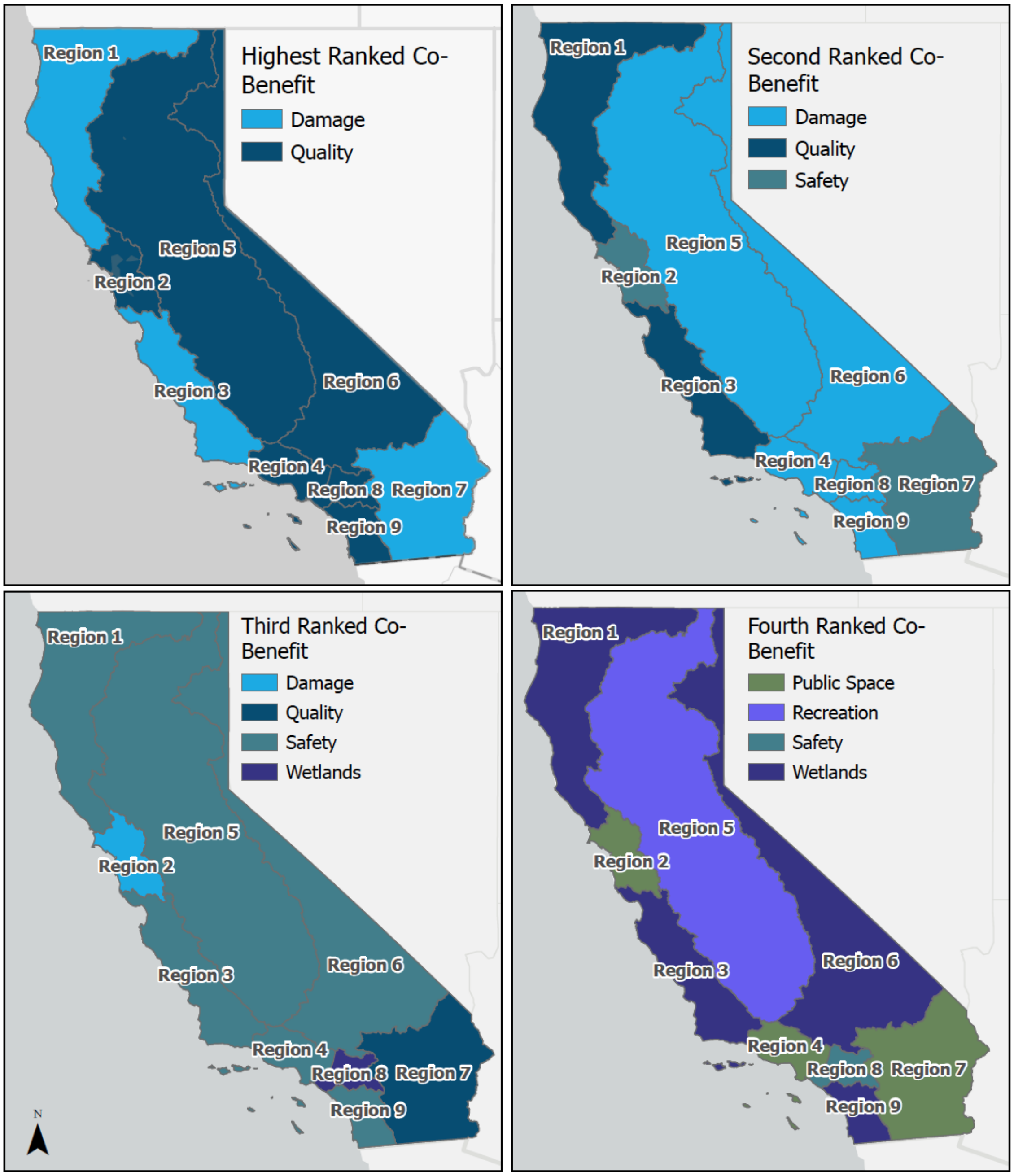


Figure 2: Maps showing regional differences in the top four ranked benefits. The map in the top left shows that every region ranked either *improved water quality* (Quality) or *reduced property damage* (Damage) as the paramount benefit of stormwater capture. *Public safety* (Safety), *wetland restoration* (Wetlands), and *public space creation* (Public Space) emerge as additional co-benefits ranked in the top four across the state.

Stormwater Capture Methods

Ceto's survey asked respondents to use their professional judgment and experience to rank which stormwater capture method would generate the most benefits, the results of which are summarized in Table 4. Of the methods included in the survey, *regional retention/detention basins* and *regional capture and use* were considered to be the most beneficial (18% and 15%, respectively). However, *bioretention* *areas* had the highest weighted average, indicating that, overall, it ranked most beneficial. *Bioretention areas* received a more consistently high rank, while *regional retention/detention basins* were viewed as very beneficial for some respondents, and much less so for others.

Table 4: Distribution of survey responses showing the relative potential benefit of various stormwater capture methods, based on the professional judgment of CASQA's members. The responses show the distribution within ranks 1 to 5, as well as the weighted average ("Score"). A high score means that option received the most high-ranking selections. However, as shown, score alone can obscure relative importance. For example, *bioretention areas* show greater variability in importance than *regional retention/detention basins*.

Benefit	Weighted Score
Bioretention Areas	7.5
Regional Retention/Detention Basins	7
Infiltration	6.5
Green Streets	6.4
Regional Capture and Use	6.3
Constructed Wetlands	6
Vegetated Bioswales	4.8
Drywells	4.4
Green Roofs	3.1
Individual Rainwater Collection	3

Stormwater Capture Methods - Prevalence in Member Regions

Ceto's survey also asked respondents which stormwater capture methods were most common in their region, the results of which are summarized in Figure 3. Respondents indicated that *bioretention areas* were the most common capture method, followed by *regional retention/detention basins*, *infiltration*, and *regional capture and reuse*. For organizations whose most common capture method was *bioretention*, this method provided anywhere from 10% to 75% of stormwater capture. The most common secondary methods for these organizations were *vegetated bioswales*, followed by *green streets*, and *infiltration*. For organizations whose most common stormwater capture method was *regional retention/detention basins*, this method provided anywhere from 25% to 100% of stormwater capture. The most common secondary method for these organizations was *infiltration*, which was indicated to provide an additional 25% of capture.

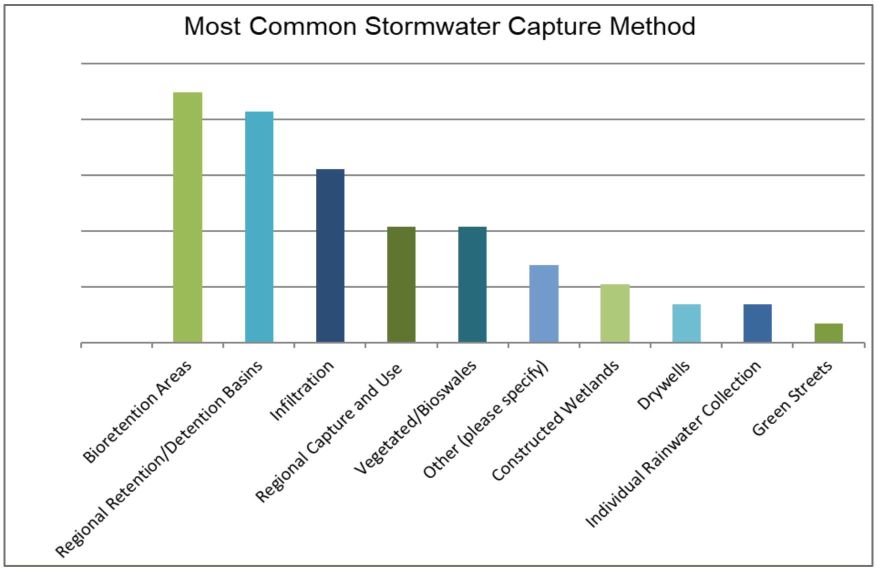


Figure 3: The distribution of responses to the survey question on the most common stormwater capture method used in respondents' regions. Responses indicate that the three most common capture methods used in respondents' regions are: (1) *bioretention areas*, (2) *regional retention/detention basins*, and (3) *infiltration*. Twenty-five percent (25%) of respondents indicated that *bioretention areas* are most used, and 24% indicated that *regional retention/detention basins* are most commonly used.

Regionality in Survey Results

As anticipated, the survey responses showed regional differences in both the importance of key socioeconomic benefits and the predominant stormwater capture methods. The maps included in Figure 4 and Figure 5 show the relative importance of each of the co-benefits and the methods of stormwater capture expected to generate the greatest co-benefits across the nine regions. Several takeaways from this analysis include:

- Region 2 (San Francisco Bay Region) assigned the lowest importance to *reduced flooding damage to property* despite high value property and placed a premium on *public safety*.
- Regions 4, 5, and 9 (Los Angeles, Central Valley, and San Diego Regions, respectively) ranked *recreation* in their top five co-benefits.
- Similarly, Regions 2, 5, and 7 (San Francisco Bay, Central Valley, and Colorado River Regions, respectively) ranked *improved community health* in their top five co-benefits.
- Region 8 (Santa Ana Region) ranked *wetland preservation or restoration* highly (rank 3) compared to other regions; although Regions 1, 3, 6, and 9 rank it in 4th or 5th place.
- *Increased agricultural yield* ranked lowest for many regions but was ranked much higher in Regions 6 and 7 (Lahontan and Colorado River Regions, respectively).
- *Bioretention areas* were thought to be relatively effective in all regions.
- *Regional retention/detention basins* were expected to generate the most co-benefits by Region 5 (Central Valley) and Region 1 (Northern California).
- In Regions 2, 3, and 4 *constructed wetland* and *vegetated bioswales* were not expected to create significant co-benefits.

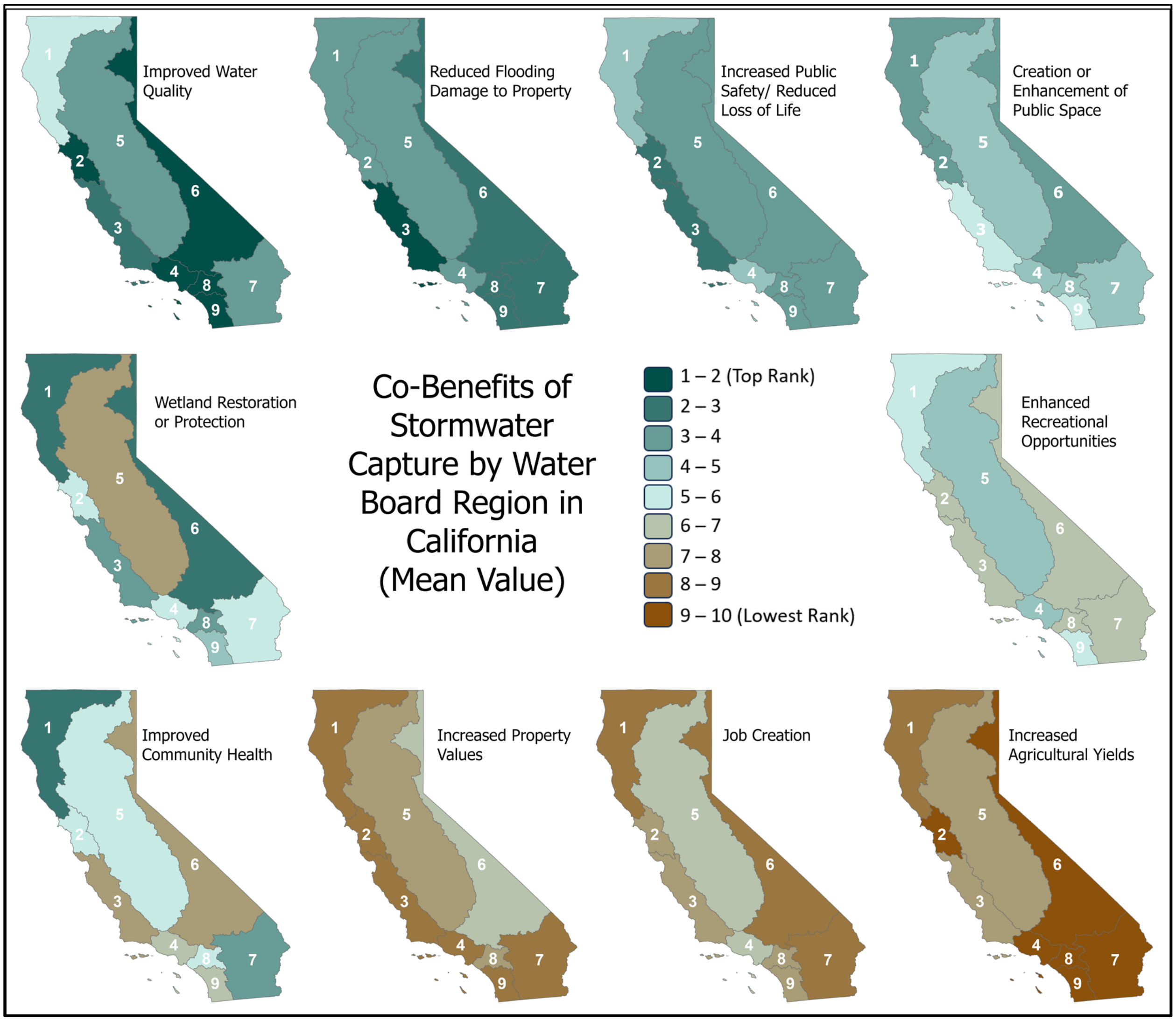


Figure 4: Geospatial analysis of the ranking of all co-benefits shows additional regional differences and commonalities in prioritization. These maps use mean value to determine rank, so the deeper color indicates a more pronounced rank for that co-benefit across all respondents in that region.

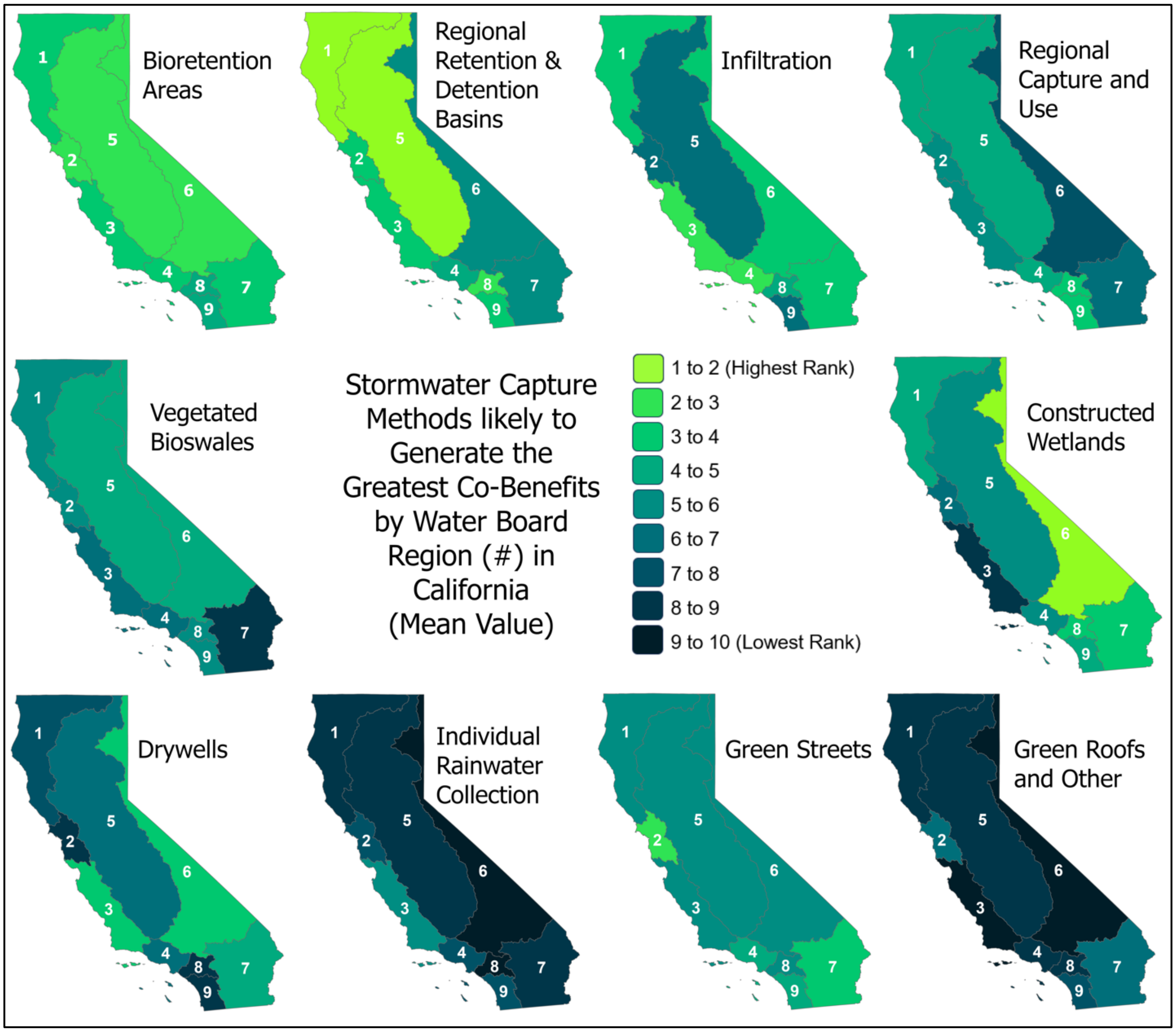


Figure 5: Geospatial analysis of the respondents' professional judgment on which stormwater capture methods generate the greatest co-benefit by region. This analysis shows that *bioretention areas* were thought to be relatively effective in all regions, while *regional retention/detention basins* and *infiltration* were thought to produce meaningful co-benefits in all but a subset of regions. The lack of *constructed wetland* and *vegetated bioswales* expected to create co-benefits in Regions 2, 3, and 4 is of note.

2.2 Interpretation of Survey Results to Inform Economic Analysis

The results of the survey were used to inform the remainder of the economic and geospatial analysis. For illustrative purposes, this report analyzes the top five socioeconomic benefits of urban stormwater capture, as indicated by CASQA members. While survey respondents indicated that *reduced flood damage to property* and *increased public safety/reduced loss of life* were important benefits, both possess readily accessible dollar values and are often considered in the cost-benefit analysis for potential projects (as discussed in previously in Section 2 of this report). This analysis focused on the socioeconomic benefits which are more difficult to quantify. In addition, these benefits relate to environmental and social justice considerations of vital importance to communities in California, which are a driving force of many current government policies and initiatives at the state and federal level.

The following benefits of stormwater capture were selected as those to be included to calculate the economic benefit of stormwater capture benefits within the scope of this project:

- Improved water quality
- Creation or enhancement of public space (e.g., urban green space)
- Restoration or enhancement of wetlands
- Enhanced recreational opportunity.
- Improved community health

Not all stormwater capture methods or project designs will generate every socioeconomic benefit. This report focuses on stormwater capture methods that incorporate green infrastructure elements, since, by design, they generate these benefits. Based on Ceto's survey of CASQA members, as well as literature review, the following methods of stormwater capture were determined to be most relevant:

- Bioretention areas[2]
- Regional retention/detention basins
- Infiltration

Based on the capture methods and the regional differences identified in the survey results, and input from CASQA staff, Ceto chose to evaluate the benefits of projects from Region 5 (Central Valley), Region 2 (San Francisco Bay), and Region 4 (Los Angeles).[3] The case studies selected, and discussed in Section 4 of this report, include:

- Los Angeles County, Earvin "Magic" Johnson Park.
- San Mateo County, San Mateo Sustainable Streets Master Plan green streets projects.
- Fresno, the Fresno Metropolitan Flood Control District retention basin system; and
- South San Francisco, Orange Memorial Park.

3. Methods: Calculating the Economic Value of Benefits

To demonstrate the value of the ancillary benefits urban stormwater capture projects can generate for surrounding communities, Ceto evaluated the socioeconomic benefits created by four urban stormwater capture projects. A GIS-informed analysis of the population of the surrounding

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[2] This project type is often combined with other project types, such as use in green street design as seen in the San Mateo Sustainable Streets Master Plan case study or the comprehensive design of an urban stormwater capture park.

[3] Region 2 showed the highest use of bioretention areas and was the only region to rank Green Streets among its top methods, thus, a case study was selected from this region which made heavy use of bioretention areas in a diffuse model (San Mateo Sustainable Streets Master Plan). Region 5 ranked regional retention and detention basins top, and therefore a regional detention basin model (Fresno Metropolitan Flood Control District) was selected. For Region 8 (Los Angeles) many methods were common, and thus a flagship project incorporating various methods and targeting underserved communities (Earvin "Magic" Johnson Park) was assessed. Finally, Orange Memorial Park in South San Francisco is included to illustrate the benefits of a smaller engineered stormwater park.

neighborhood determined the benefits generated by each project, and a benefit-transfer method was applied to estimate the annual value.

3.1 Ecosystem Functions Goods and Services and Non-Market Value

In natural resource economics, the socioeconomic benefits of urban stormwater capture are called "ecosystem goods and services," which refers to the ways in which the environment is enjoyed, consumed, or used to improve human well-being. Liu et al. (2010) describe ecosystem services as, "components of the natural environment which provide a long-term stream of benefits" to individuals and society. The value of these benefits is often well beyond the goods and services which are traded in organized markets; however, ecosystem services also include the raw materials extracted from the environment which are exchanged. In the case of stormwater capture systems, water is the market good, typically expressed in value per gallon (for consumers) or per acre feet (for resource managers).

The monetary value of the ecosystem to the public depends on the benefit people derive from its services. Ecosystem services can be categorized in several different ways. There are *use values* and *non-use values.* Typically, use values involve some human ‘‘interaction’’ with the environment, whereas non-use values do not, as they represent an individual valuing the pure ‘‘existence’’ of a natural habitat or ecosystem (Barbier, 2011; Barbier, 2007; Barbier et al., 1997; Mehvar, 2018). Direct-use values refer to both consumptive and non-consumptive uses that involve some form of direct physical interaction with environmental goods and services, such as recreational activities, resource harvesting, drinking clean water, breathing unpolluted air, and so forth (Barbier, 2011). Non-use values are based on the existence of the ecosystem, irrespective of human consumption (Mehvar, 2018; Raheema et al., 2009).

This assessment primarily considers ecosystem services that provide direct and indirect use value. Ecosystem services are categorized into four types: provisional, regulating, supporting, and cultural (Chivian & Bernstein, 2008; Environmental Protection Agency, 2000; Raheema et al., 2009; Shaw et al., 2011). This categorization overlaps with use and non-use values, depending on the type of benefit provided. The first category, provisioning, is generally focused on providing physical services, such as food or timber. These goods and services typically have an associated market value. In the case of stormwater capture, the use or offset of potable water, valued at market prices, would be an example.

Diringer et al. (2020) focus on the provisioning services of stormwater. However, as mentioned previously, stormwater retention creates many additional regulating and cultural services which are not valued in this approach. For example, stormwater capture projects can incorporate planting additional trees, creating green space, and enhancing wetlands, all of which provide climate regulation, and disease prevention through health benefits (e.g., lowering the impact of extreme heat events), as well as recreational, cultural, and aesthetic services (e.g., public parks). Although Diringer et al. (2020) have estimated the provisioning services of stormwater capture, little work has been done valuing the non-provisioning ecosystem services provided by stormwater.

In this analysis, the non-market value of the cultural and regulating services provided by urban stormwater capture is estimated via 1) the willingness to pay for these services, or 2) the "avoided costs" of additional morbidity or mortality. For example, recreation and water quality values are determined by willingness to pay, while the community health benefits are based on the avoided morbidity and mortality costs.

The estimated values are applied via a *benefits transfer* method, which involves, "obtaining an estimate for the value of ecosystem services through the analysis of a single study or group of studies which have been previously carried out to value similar goods or services," and applying that estimated value to the site in question (Liu et al., 2010).

There are two methods of benefit transfer calculation. First, *function transfer* assumes, "there is uniform function between two sites," and applies estimates based on the value of that function. Alternatively, *point transfer* requires separating ecosystems into spatial units, and assumes that the two *locations* are similar enough to apply the value from the primary data (Liu et al., 2010). With the point transfer approach, it is important to utilize primary data from sites and surveys similar in location and demographics to the project location. Often, benefit transfer involves calculation of the average value for a particular amount of a particular ecosystem service—for example, per acre of wetland—and applying that value to the amount at the project site.

This report makes use of both function transfer and point transfer, depending on the benefit. For those benefits focused on direct use of the project site (e.g., physical and mental health, recreation, and urban green space), functional transfer methods are used, looking at the value of the function per user. For regulating services, point transfer is used. For accurate benefit transfer, the chosen estimates must come from quality research that shares common characteristics with the project site. Furthermore, value estimates often must be converted to current United States dollars (USD) adjusting for inflation. This report makes use of peer-reviewed and government-supported analyses to provide accurate and data-supported estimates. The specific benefit transfer method employed for each co-benefit is discussed in the following sections. Table 5 summarizes the five different benefits estimated for this assessment and the valuation methods/techniques that were used in the studies applied.

Table 5: Ecosystem services and method applied.

Service	Valuation Method	Technique
Urban Greenspace	Hedonic	Increased Home Values
(Park) Recreation	Travel Cost	Travel Cost
Water Quality	Willingness to Pay	Survey
Community Health	Avoided Cost	Avoided Morbidity/Mortality
Wetlands	Full Benefit Transfer	Benefit Transfer

3.2 Urban Green Space

The term "urban greenspace" (or "urban green space") is widely used in academic and non-academic literature. In its original and broadest definition, urban greenspace simply meant space within an urban setting that is somehow vegetated (Taylor & Hochuli, 2017). This analysis considers the types of urban greenspace created by stormwater capture projects. Following Taylor and Hochuli (2017), the types of greenspaces created can be considered in different tiers based on the ecosystem services provided:

1. Spaces that are simply "vegetated," which can help improve water quality and enhance infiltration.
2. Vegetated spaces with *trees,* which provide additional benefits such as improved air quality.
3. Urban parks with vegetation and amenities, which provide a wide variety of additional services and recreational opportunities.
4. Urban and peri-urban wetlands[4] provide additional ecological services (e.g., bird migration). Since wetlands are relatively rare in urban areas, their ecological value is higher than in other settings, as discussed below.

The estimates of the benefits of urban green space follow the above taxonomy, with projects providing a higher tier of urban green space generating a higher ecosystem service value. Where applicable to project design, this report estimates the distinct recreational benefits of developed urban parks, the added benefits of urban wetland creation or enhancement, and community health benefits. Immediate proximity to urban green space has a value independent of these additional benefits (Bertram, 2014; Center for Neighborhood Technology (CNT), 2020; Dai et al., 2021; Dunse et al., 2007; FEMA, 2022; GLA Economics, 2003; Harnik et al., 2017; Harnik et al., 2009; Harvard Kennedy School, 2003; Wilson & Xiao, 2023). Studies estimating this value assume that the amenities provided by parks and urban green space will increase the (private) property values of residential property in the area surrounding the park/greenspace (Bertram, 2014; Dunse et al., 2007; GLA Economics, 2003; Saraev, 2012; Tiwary et al., 2009). Considering the tiers of urban green space, the economic value of an urban greenspace which <u>only</u> has vegetation will be lower than a fully developed park with recreational amenities or an urban wetland. Dunse et al. (2007) findings confirm this distinction, with increases of 10.1% for "city parks," 9% for "local parks," and 2.6% for "amenity greenspace." Drawing on the existing literature, the value of proximity to urban green space is measured as the percentage increase in home values within 100 meters of the site, as shown in Table 6 below. For urban greenspace with recreational amenities, an average value of 4% was derived from the studies. For urban greenspace with vegetation alone, a reduced value of 1% was derived from the findings of a 2003 GLA study and the value of "amenity greenspace" in Dunse et al., which most closely match the conditions found in the case study projects.

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[4] Peri-urban refers to wetlands located in zones of transition from rural to urban land uses located between the outer limits of urban and regional centers and the rural environment.

Table 6: Percent property value increase from urban greenspace.

Study	Percent Increase in Property Value
Dunse et al. (2007)	10.1%
Dunse et al. (2007)	9.1%
Dunse et al. (2007)	2.6%
GLA Economics (2003)	0.5%
Tiwary et al. (2009)	5%

3.3 Recreation

While valuing urban green space using hedonic methods (essentially the impact that greenspace has on property values) captures some of the value of green open space, it does not fully capture the value of the *recreational use* of that space. The ability to access a park for recreational activities such as walking, jogging, picnics, children's play areas, and organized sports has a value to those users. Urban parks are considered readily accessible to those living within an approximately 10-minute, or half-mile, walk (Wilson & Xiao, 2023). In Ceto's survey of CASQA members, recreational opportunities were ranked of moderate importance across California, and of high importance to Regions 4 and 5 (Los Angeles and the Central Valley) (see Section 2.2).

The most comprehensive database of outdoor recreation studies is from Oregon State University, which contains over 3,000 studies, most in the United States or Canada (Rosenberger, 201). The Trust for Public Land (TPL) analyzed this database in their review of city parks in Los Angeles. TPL estimated the value of one visit to an urban park in Los Angeles at $2.86 per visit in 2016 dollars, which translates into $3.65 per visit in 2023 dollars (Harnik et al., 2017). Following Wilson and Xiao (2023) and Burrowes et al. (2022), it was assumed that 27% of the population within a half-mile radius of the parks uses them for recreation.

However, not all urban green space created as part of stormwater capture will create a recreational benefit. Small bioretention areas, wetlands, and green streets, for example, do not generate significant recreational benefits (Center for Neighborhood Technology (CNT), 2020). On the other hand, recreational benefits are created by anything from open fields to full park amenities at urban parks that are built as part of a stormwater capture project. The more amenities provided, such as courts, play areas, and lighted fields, the more recreational benefits a park project will generate. However, for the purposes of this assessment, Ceto employed a consistent average valuation to parks. If one wanted to apply this method for a specific stormwater capture project, site-specific information on amenities, expected use, and existing recreational opportunities should be considered to inform the value applied to the site (see Section 6 for additional discussion).

3.4 Water Quality

Survey respondents from all regions indicated water quality as one of the most important benefits of stormwater capture projects (see Section 2.1). Water quality ranked number one in six regions and ranked within the top three in all nine regions. The importance of water quality is underscored by the wide array of water quality regulations that exist at the local, state and federal level, including requiring an economic assessment of the potential benefits (Viscusi et al., 2008). In the United States, the EPA is the primary federal agency regulating freshwater quality and they consider that a water body is "impaired" if it does not meet an applicable water quality standard (U.S. Environmental Protection Agency (EPA), 2022). Maintaining unimpaired, high quality bodies of water is a priority nationwide (Holm et al., 2014; Kreye et al., 2014).

Stormwater capture projects can improve water quality and help maintain already unimpaired bodies of water by limiting pollutant loading through treatment, regulating flow, or both (U.S. Environmental Protection Agency (EPA), 2022). In addition, studies have shown that green infrastructure can aid in water filtration and reducing harmful pollutants, especially those found in stormwater runoff (Cooley et al., 2019). Vegetation planted for green infrastructure not only increases infiltration but increases the pollutant removal function of the soil (Jones et al., 2015; Symons et al., 2015). In both water rich and water scarce regions of the United States, water quality is a motivating factor in the implementation of stormwater capture and use projects (U.S. Environmental Protection Agency (EPA), 2022).

Water capture and filtration is an ecosystem service provided by green infrastructure. This is a *regulating* function of a healthy ecosystem.[5] This function has an associated value beyond the cost of a green infrastructure project. Several studies have monetized the value of maintaining good quality water or improving impaired water quality.

These studies survey communities to determine the value of good water quality, determining their "willingness to pay." Using iterative stated preference models, Viscusi et al. (2008) estimated the value of an increase in the percent of regional lakes and rivers of "good" quality at $45 per person per year per percentage increase (2023 dollars). At the time of their study, water quality was considered "good" if it was safe for all non-drinking uses, and "not good" if it was unsafe or polluted. At a regional level, they found that participants were willing to pay to increase the quality of water that was within 100 miles of their home (a two-hour drive) (Viscusi et al., 2008). However, narrowing the focus to nearby bodies of water increased the value of good water quality–especially to improve impaired bodies of water—to an average of $200 per year, per individual in the service area (Dai et al., 2021; Kauffman, 2011; Kreye et al., 2014; Nelson et al., 2015). While the benefits of good water quality to health, recreation, and environment are distributed across a watershed region, the most immediate impact will be to those with ready access to bodies of water (Dai et al., 2021). Table 7 shows the values informing this analysis. These studies sampled a wide range of scale, including watershed level. For this study, the most

[5] Note: Improved drinking water quality is among the provisioning ecosystem goods and services provided by stormwater capture that are excluded from our analysis. Drinking water has a distinct economic valuation typically based on the market price.

conservative service area was employed, restricting benefits to the population within 2 miles of a project site.[6]

Table 7: The economic value of improved or maintained water quality to individuals in the service area.

Study	Value ($ 2023), annually per individual
Kauffman (2011)	$239.14
Dai et al. (2021)	$100.27
Nelson et al. (2015)	$190.00
Nelson et al. (2015)	$401.57
Kreye et al. (2014)	$73.01
Average	$200.80

3.5 Community Health

Increasingly, community health is a key consideration in policy making, regulatory decisions, and infrastructure planning. This is in part because these decisions can impact the lived environment, and environmental conditions play a significant role in determining community health and associated health outcomes. Community health comprises several components including physical and mental health, life satisfaction, and social wellbeing (Jones et al., 2015; Symons et al., 2015; Wilson & Xiao, 2023; Wolf et al., 2015).

An additional crucial consideration for California are urban heat islands (UHI) and their effects on mortality and morbidity (Jones et al., 2015; Symons et al., 2015; The Nature Conservancy & AECOM, 2021). UHI is particularly important as global average temperatures rise and heat waves occur with increasing frequency due to climate change. Some studies of community health also include social cohesion and crime; however, these studies are not often monetization or valuation studies (Burrowes et al., 2022; Wolf, 2020; Wolf et al., 2015). Lack of investment in community health can impose significant public costs, in particular health inequity (Wolf, 2020). A National Institute of Health-funded study estimated that for the year 2018, health inequities cost the United States $451 billion (LaVeist et al., 2023).

Stormwater capture investments can impact community health, especially in low-income and marginalized communities. By incorporating green infrastructure, stormwater capture projects can provide *regulating ecosystem service*s, including improving air quality and regulating temperature (Center for Neighborhood Technology (CNT), 2020; FEMA, 2022; Jones et al., 2015; Symons et al., 2015).

[6] When incorporating socioeconomic benefit analysis into the cost-benefit estimates for a proposed project, estimates could be refined by precision estimates of visitors and user profiles for a proposed site. Furthermore, if the project will benefit a major body of water in the watershed, the users of that secondary site would also benefit from increased water quality and should be included in the estimate.

In addition to regulating services, large scale projects which create urban green spaces can provide “cultural” services such as recreation and social space, which result in improved mental and physical health (FEMA, 2022; Wolf, 2020; Wolf et al., 2015).

To capture a comprehensive estimate of community health benefits from urban stormwater capture projects, community health was broken into four impact areas: mental health, physical health, UHI, and improved air quality:

- Mental health: The economic impact of mental health improvements is derived from reductions in ADHD and mood disorders, along with improvements in life satisfaction (Wilson & Xiao, 2023; Wolf, 2020; Wolf et al., 2015).
- Physical health: The economic impact of physical health improvement is largely based upon the impacts that increased opportunities for physical activity from parks and urban green spaces have on improving cardiovascular outcomes and related health effects, as well as reducing medical costs (Burrowes et al., 2022; Wilson & Xiao, 2023).
- UHI: Reduction in UHI effects has a significant economic impact, including decreased heat-related mortality and morbidity, and hospitalizations and emergency room visits due to extreme heat (The Nature Conservancy & AECOM, 2021). Morbidity refers to the correlation between extreme heat and negative, non-life-threatening health impacts that require hospitalization and is determined via patient health care costs for heat related hospitalizations, while mortality refers to excess deaths from direct heat exposure and related effects (The Nature Conservancy & AECOM, 2021). There is extensive literature on UHI and its impacts, which has been synthesized into federal guidance on valuing the UHI impact of green infrastructure (Center for Neighborhood Technology (CNT), 2020).
- Air quality: Similarly, air quality economic impacts are based on federal guidance (Center for Neighborhood Technology (CNT), 2020).

Wilson and Xiao (2023) applied an “ecohealth” methodology to evaluate the economic benefits of the health benefits of a new urban park. The analysis focused on physical health benefits from increased physical activity, mental wellbeing from time in nature, and enhanced air quality (Wilson & Xiao, 2023). Their method serves as a conservative model for this analysis, as they examined a small urban park (1.2 acres), while many of the parks in this assessment are larger. However, this 1.2-acre park still generated significant health benefits despite its small size and limited amenities.

Wilson and Xiao (2023) employ a one-half mile service area for health benefits, while health values were generated from a meta-analysis that also incorporated United States-based studies to account for differences in healthcare costs (Burrowes et al., 2022). The one-half mile service area accounts for the expected frequency of park use necessary to generate health benefits: those who live in closer proximity to the park are more likely to visit sufficiently to generate a change in health outcomes that would result in avoided costs. Similarly, the value of improvement in mental well-being is based on avoided healthcare costs and the economic burden of mental illness (Wilson & Xiao, 2023; Wolf, 2020; Wolf et al., 2015). Table 8 shows relevant physical health benefit estimates.

Table 8: Physical healthcare benefit estimates.

Study	Value ($ 2023), annually per individual
Burrowes et al. (2022)* Meta-analysis	$368.55
Burrowes et al. (2022) * Meta-analysis	$737.10
Burrowes et al. (2022) * Meta-analysis	$380.12
Burrowes et al. (2022)* Meta-analysis	$722.40
Burrowes et al. (2022)* Meta-analysis	$1,291.50
Burrowes et al. (2022)* Meta-analysis	$2,526.30
Harnik et al. (2017)	$1,500.43
Harnik et al. (2017)	$3,000.84
Average	$1,315.91

To determine the impact of improved air quality and reductions in UHI, this analysis relies on the Federal Emergency Management Agency's (FEMA) guidance, and therefore estimates the economic benefits because of tree planting (Center for Neighborhood Technology (CNT), 2020). The precise impact of additional trees depends on the existing tree canopy in the area and the climate conditions regarding excessive temperature (Center for Neighborhood Technology (CNT), 2020; The Nature Conservancy & AECOM, 2021; Wilson & Xiao, 2023). As this study applies a consistent methodology across all projects within California, it applies the conservative federal guidelines. Similar to physical health, these impact estimates are primarily based on avoided medical costs (Center for Neighborhood Technology (CNT), 2020; Harnik et al., 2017).

Table 9 presents the inflation-adjusted recommended values.

Table 9: Relevant FEMA non-market value recommendations for health impacts of tree planting (Center for Neighborhood Technology (CNT), 2020).

Benefit	FEMA Recommended Economic Value
Improved Air Quality	$5 per tree planted
Reduced Urban Heat Island Effect	$1,000 per tree planted

3.6 Wetland Creation or Enhancement

Wetlands provide a wide variety of ecological services including providing wildlife habitat, improving water quality, providing resting places for migrating birds, and storing floodwater. The economic value of wetlands has been widely studied as a dollar per acre value. Diaz-Pinzon et al. (2022) indicates that urban and peri-urban wetlands have higher ecological value than other wetlands due to their scarcity.

The Diaz-Pinzon et al. (2022) study of urban and suburban areas estimates the value of an urban wetland at $198,000 and $78,000 for peri-urban wetland. There is a great deal of variation in wetland value, for example, Costanza et al. (1997) values the world's wetlands at an average value of $109,000 per acre (adjusted for inflation), whereas a 2010 study of New Jersey's wetlands estimates a value of $41,000 per acre (Costanza et al., 1997; Liu et al., 2010). Table 10 summarizes these estimates. Ceto's analysis uses an average of the four estimates ($106,500 per acre) which is also close to the Costanza et al. (1997) estimate for the world average ($109,000 per acre).[7]

Table 10: Value of wetlands per acre.

Study	Value ($ 2023), annually per acre
Diaz-Pinzon et al. (2022)	$198,000
Diaz-Pinzon et al. (2022)	$78,000
Costanza et al. (1997)	$109,000
Liu et al. (2010)	$41,000
Average	$106,500

4. Case Studies

To demonstrate the value of urban stormwater capture project adoption in California, Ceto applied the socioeconomic benefit values to four existing stormwater capture projects as case studies: Earvin "Magic" Johnson Park in Los Angeles, the San Mateo Sustainable Streets Master Plan, Fresno Metropolitan Flood Control District's recreation-type retention basins, and Orange Memorial Park in South San Francisco. These projects were chosen with CASQA's input to reflect ongoing work in the state and the types of urban stormwater capture methodologies most commonly employed, per the member survey (see Section 2). Furthermore, these project selections reflect regional differences in urban stormwater capture methods, such as the prevalence of bioretention areas and green streets in Region 2 (the San Francisco Bay Area), regional retention and detention basins in Region 5 (San Joaquin Valley), and regional parks in the Los Angeles area. In addition, these case studies highlight the differences in benefits based on urban stormwater capture methods, and how those differences may factor into statewide policies and decision making at the local level.

As outlined in Section 2, Ceto selected the following socioeconomic benefits to be evaluated for each case study:

- Improved water quality
- Creation or enhancement of public space (e.g., urban green space)
- Restoration or enhancement of wetlands
- Enhanced recreational opportunity.
- Improved community health

[7] This value is significantly lower than the Diaz-Pinzon, L., Sierra, L., & Trillas, F. (2022). The Economic Value of Wetlands in Urban Areas: The Benefits in a Developing Country. *Sustainability*, *14*, 8302. https://doi.org/https://doi.org/10.3390/su14148302 study estimate for urban wetlands; however, since this study is also considering water quality and recreation, we believe a value almost half of their estimate is appropriate.

It should be noted that not all of the case studies generated all of these benefits. The following section provides descriptions of the four urban stormwater capture case studies and summarizes the inputs used in the economic analysis, the results of which are included in Section 5.

4.1 Earvin "Magic" Johnson Park

Earvin "Magic" Johnson Park in the Willowbrook neighborhood of South Los Angeles is a recent example of how to combine large-scale stormwater capture with significant environmental, social, cultural, and recreational benefits. Historically, the site was an oil storage and processing facility, which was later turned into a basic park that used 100% potable water for landscape irrigation and to fill two artificial lakes (Chan, 2022; Sharp, 2021). In 2018, Los Angeles County adopted a revised Master Plan to capture and treat stormwater on site, while adding much needed amenities and improvements to the park (County of Los Angeles Department of Parks and Recreation, 2018). The project was completed in 2022 (Los Angeles County Parks & Recreation, 2022). Earvin "Magic" Johnson Park, at 126 acres, is the largest open space in South Los Angeles and is now an important recreational and social hub for the surrounding underserved community. The park has a new community center and social spaces, play areas, walking paths, picnic areas, outdoor classrooms, and a wedding area, and it contributes to the health of the community by encouraging outdoor activity and improving the quality of life (MIG, 2023; US Green Building Council Los Angeles, 2021).

The new stormwater system at Earvin "Magic" Johnson Park (Figure 6) captures urban runoff (dry and wet weather first-flush flows) from a 375-acre portion of the watershed of Compton Creek (Chan, 2022). The water is diverted into a small pumping station where garbage and debris are removed. From there, the water is piped into a small treatment plant near the park's community center and is treated with alum and ozone. The treated water is then slowly released into newly planted wetlands that border the park's southern lake. As such, the water receives another level of cleaning as it filters through native wetland plants as well as a porous stone barrier. Once the water has been cleaned in the treatment plant and via biofiltration in the wetlands, it is stored within both lakes and is used to irrigate the park or is released back into Compton Creek (County of Los Angeles Department of Parks and Recreation, 2018; Los Angeles County Parks & Recreation, 2022; Miranda, 2021).

The project provides a wide range of socioeconomic benefits. For example, stormwater capture has offset potable water consumption; the park now uses treated water for all park irrigation and to fill the lakes (except during the driest periods). In addition, the water treatment steps improve water quality not only in Compton Creek, but also the Los Angeles River and the Pacific Ocean (PACE, 2022). With the addition of wetlands, trees, and overall landscape improvements, much needed wildlife habitat has been added to an intensely urban area (Miranda, 2021). In fact, the cleaner water has attracted new bird species to an artificial island at the center of the lake, which was designed to accommodate nesting (Sharp 2021). The stormwater capture system is also designed to provide flood control during large storm events, by capturing up to the 85th percentile 100-year storm event (PACE, 2022). Lastly, the renovated Earvin "Magic" Johnson Park has provided important human health and societal benefits, including providing safe space for healthy recreation, gathering, and appreciation of nature in an otherwise highly urbanized setting that historically lacks quality green spaces (County of Los Angeles Department of Parks and Recreation, 2018; Los Angeles County Parks & Recreation, 2022; Miranda, 2021).

Figure 6: Illustration of the Earvin "Magic" Johnson Park runoff recycling process (PACE, 2022)

Table 11: Summary of values used to calculate socioeconomic benefits for Earvin "Magic" Johnson Park, South Los Angeles.

Parameter	Earvin "Magic" Johnson Park
Type of Project	Stormwater capture and treatment in a large multi-use urban park incorporating **bioretention, wetland creation, infiltration.**
Acreage	126 acres
Population within 0.5 Mile	21,869
Population within 2 Miles	202,782
Located in an Underserved Community per CalEnviroScreen vulnerability	Yes
Estimated Number of Trees	300 "new" trees (and 30,000 plants) (Powell, 2020)

4.2 San Mateo Sustainable Streets Master Plan

The Sustainable Streets Master Plan (the Master Plan) was developed by the City/County Association of Governments of San Mateo County in 2021 as a long-term planning effort to promote and guide the adoption of green streets projects throughout the county. The Master Plan, based on years of watershed modeling and stakeholder engagement, supports the San Mateo Countywide Water Pollution Prevention Program, which was established in 1993 to reduce the pollution carried by stormwater into local creeks, the San Francisco Bay, and the Pacific Ocean. The Master Plan provides vital information and guidance for local governments on how and where to build sustainable streets that incorporate stormwater management with a variety of other benefits, including bicycle and pedestrian safety, transit improvements, and urban tree canopy expansion (see Figure 7). Importantly, the Master Plan also includes climate change metrics to understand how future precipitation changes can be managed by green stormwater infrastructure (C/CAG of San Mateo County, 2021; Flows to the Bay, 2021).

This case study is based not on a single project, but on the cumulative benefits from many small-scale distributed sustainable streets projects built throughout San Mateo County leading up to and after the completion of the Master Plan. To date, 41 sustainable streets projects have been completed in San Mateo County (according to the County's GIS database). Details for the cumulative projects are shown in Table 12. The average area for these projects is 1.1 acres and the total area for all the projects completed to date is 47 acres. Most of these projects include improvements to an intersection and/or a section of road. They typically include features such as stormwater curb extensions with bioretention planters integrated with bike and pedestrian improvements. In other instances, bioretention areas (or rain gardens) were added to public parking lots to treat stormwater. The type of plants (e.g., trees and/or low vegetation) and the type of stormwater infrastructure depends on the site conditions and needs (Flows to the Bay, 2023).

Table 12: Summary of values used to calculate socioeconomic benefits for the San Mateo Sustainable Streets Master Plan.

Parameter	San Mateo Sustainable Streets Master Plan
Type of Project	Collection of small county-wide sustainable/**green street** projects incorporating small **bioretention** areas
Number of Individual Project Sites	41
Total Acreage	46.7 acres
Population within 0.5 mile of all sites	179,820
Population within 2 miles of all sites	699,448
Located in an Underserved Community per CalEnviroScreen vulnerability	Some sites, for full project area only 9% most vulnerable.
Estimated Number of Trees	336, trees in 44% of all projects

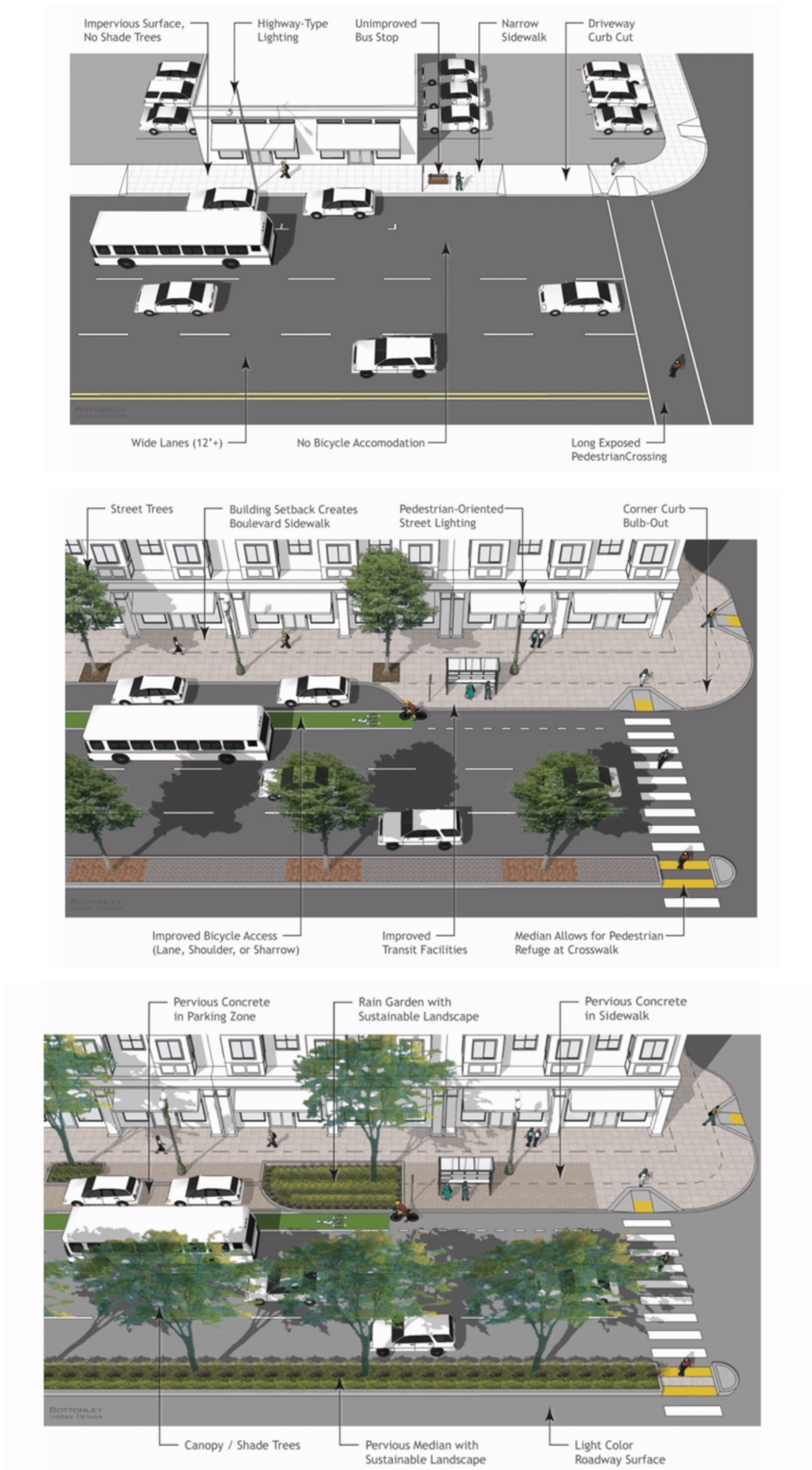

Figure 7: Progression of a street from a regular street (top) to a “complete street” (middle) to a “sustainable street” (bottom) that meets the guidelines set out in the Sustainable Streets Master Plan (Flows to the Bay, 2023).

4.3 Fresno Metropolitan Flood Control District

The Fresno Metropolitan Flood Control District (FMFCD) operates 150+ stormwater basins to capture and control stormwater and urban runoff. The FMFCD was created in 1956 and now provides permanent, local drainage service for the Fresno-Clovis metropolitan area and unincorporated lands to the east and northeast (Fresno Metropolitan Flood Control District, 2023a, 2023b, 2023c, 2023d, 2023e, 2023f). For planning purposes, FMFCD makes a distinction between flood control and local drainage services. The flood control program relates to the control, containment, and safe disposal of stormwater that flows onto the valley floor from the eastern streams, encompassing a watershed of 399 square miles (Fresno Metropolitan Flood Control District, 2023b, 2023e, 2023f). The local drainage program relates to the collection and safe disposal of stormwater runoff generated within the urban and rural watersheds or “drainage areas.” Together, these facilities comprise the Storm Drainage and Flood Control Master Plan (Fresno Metropolitan Flood Control District, 2023a, 2023d).

The FMFCD’s local urban system for storm water drainage consists of storm drains, 150+ detention and retention basins, and pump stations. Stormwater flows into storm drain inlets, and through a network of over 700 miles of underground pipes to nearby ponding basins, which range in size from six (6) to 40 acres. The system is designed to retain and infiltrate as much stormwater and urban runoff as possible. The Storm Drainage and Flood Control Master Plan includes 158 drainage areas, each providing service to approximately one to four square miles. All but five of the developed drainage areas are served by a retention or detention facility (Fresno Metropolitan Flood Control District, 2023b, 2023f).

Once in the stormwater capture basins, the water is stored to protect neighborhoods from flooding and to replenish the groundwater aquifer, which is the primary source of drinking water (Fresno Metropolitan Flood Control District, 2023e). The stormwater capture basins are helping to reverse the region’s groundwater overdraft, which FMFCD has worked on as part of the North Kings Groundwater Sustainability Agency. In 2020, FMFCD basins recharged 48,139 AF of water (over 15 billion gallons) (Fresno Metropolitan Flood Control District, 2023e).

Many basins within the stormwater capture system in the Fresno region also provide recreational and community benefits. Twenty-three (23) basins have a recreation component with either parks with playgrounds/sports fields and/or open green space (see Figure 8 and Figure 9). This use of public facilities for multiple uses has added 250 acres of recreation space to a community that generally lacks green space opportunities. Most park sites are open during the dry season, when the basins are not needed to control stormwater; a handful of these parks are open year-round. Two parks, Sloan Johnson Oso de Oro Lake Park, and Trolley Creek Park have won awards for providing accessibility to visitors of varying physical abilities (Fresno Metropolitan Flood Control District, 2023b, 2023c; Harvard Kennedy School, 2003). Details for the cumulative 22 recreation basins used in our analysis are shown in Table 13.

Figure 8: Example of a stormwater capture basin in the FMFCD system surrounded by limited greenspace (Fresno Metropolitan Flood Control District, 2023b).

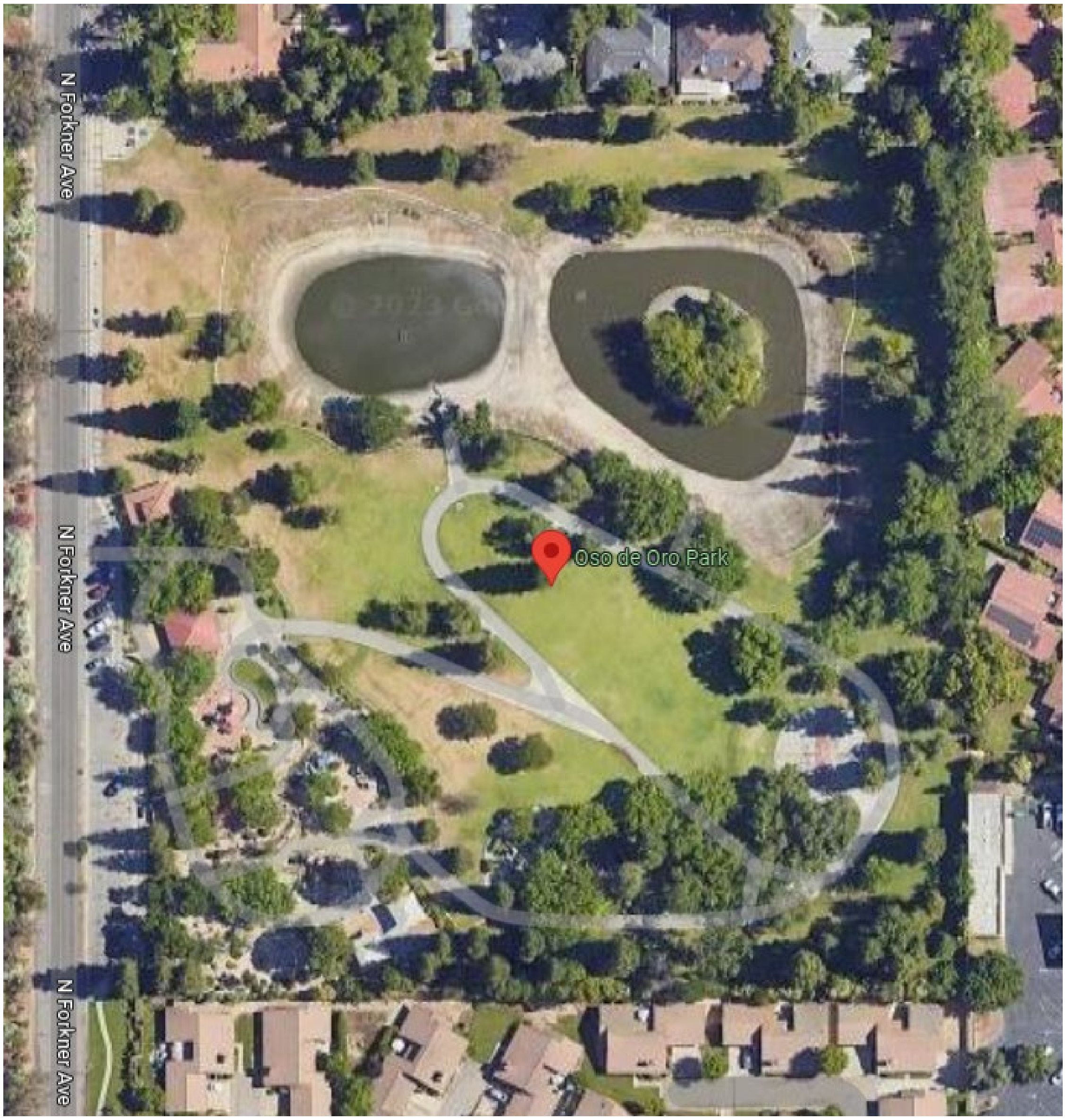

Figure 9: Google Maps aerial image of Oso de Oro Park in Fresno with its stormwater capture basins, walking trails, and handicapped accessible playgrounds (Accessed October 27, 2023).

Table 13: Summary of values used to calculate socioeconomic benefits for the Fresno Stormwater Basin System.

Parameter	Fresno Stormwater Basin System
Type of Project	System of stormwater capture regional retention basins
Acreage	**246** acres converted into 22 parks out of 8,662 total acres of retention basins.
Population within 0.5 mile of all converted sites	105,945
Population within 2 miles of all converted sites	532,198
Located in an Underserved Community per CalEnviroScreen vulnerability	**61%** of population within 0.5 mile of recreation basins in highest vulnerability
Estimated Number of Trees	1,127 (at the 22 sites with parks and green space)

4.4 Orange Memorial Park

Orange Memorial Park in South San Francisco is an example of a regional stormwater project that captures water from a large, multi-jurisdictional drainage area, while also providing significant public benefit. The San Mateo County Stormwater Resource Plan (SRP) identified Orange Memorial Park as an ideal location for an underground stormwater capture project to reduce the amount of mercury and polychlorinated biphenyls (PCBs) in stormwater discharges to the San Francisco Bay, which is a requirement of the Municipal Regional Stormwater Permit. The resulting regional stormwater capture project, the first-of-its-kind in the Bay Area, diverts all dry-weather flow and the dirty first flush of urban stormwater runoff from Colma Creek into an underground system integrated within the park. The section of Colma Creek running through Orange Memorial Park drains a watershed of over 6,500 acres within six municipalities (City of South San Francisco California, 2021, 2023a). The stormwater capture component of this project was completed in 2022 (Flows to the Bay, 2021).

Figure 10 shows a schematic diagram of how the Orange Memorial Park stormwater capture system works. Water is first diverted from Colma Creek where trash and sediment are removed, and then travels to an underground cistern for additional treatment. From the cistern, water is pumped into a water treatment facility to clean the water further and then to be used for irrigation in the park and along Centennial Trail, for water trucks, and for other non-potable water use. When the cistern is full, water will overflow to an infiltration gallery for groundwater recharge. When capacity in the storage system is exceeded, the system will remove trash and debris from water that is returned to Colma Creek (City of South San Francisco California, 2023a, 2023b; Furtell & Liu, 2022).

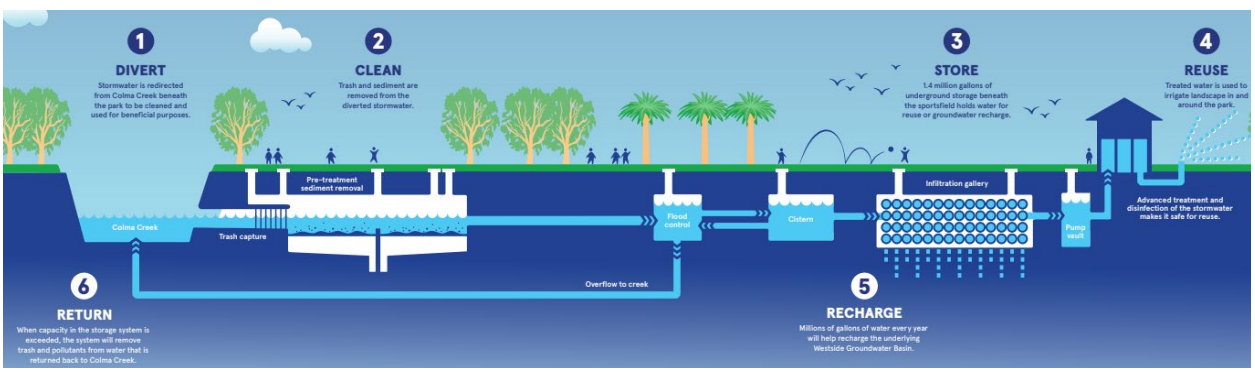

Figure 10: Schematic diagram of the Orange Memorial Park stormwater capture system (City of South San Francisco California, 2023b)

Planners also saw an opportunity to make recreational and aesthetic park improvements in collaboration with the stormwater capture project. Before the project, the site was an outdated athletic field that was only suited for baseball/softball and was chronically underused because it could not be played on during or after wet weather. Phase 2 of the project, completed in Fall 2023, includes enhanced recreational opportunities for the local community, providing a space for baseball, softball, and soccer on artificial turf fields that can be used in more varied weather conditions. As part of the renovation, the fields now include enhanced planting areas (City of South San Francisco California, 2023a).

Beyond the recreational and community benefits, the Orange Memorial Park stormwater capture project has significant benefits in terms of water quality, flood control, offset of potable water consumption, and groundwater recharge. During storms, when the underground water storage system is full, 130 million gallons of cleaned water will be returned to Colma Creek, improving the water quality in the creek and San Francisco Bay (Flows to the Bay, 2021). In addition, it is estimated that 10 grams of PCBs and 30 grams of mercury will be removed annually (C/CAG Resource Management and Climate Protection Committee, 2021). The project provides 1.8 million gallons in storage that is fully activated during a flood event and helps protect surrounding neighborhoods, portions of which are in the FEMA 100-year floodplain (City of South San Francisco California, 2021). The system at Orange Memorial Park uses 15 million gallons of treated stormwater to irrigate three local parks, thereby reducing potable water consumption with an estimated $140,000 annual savings (C/CAG Resource Management and Climate Protection Committee, 2021). Finally, the project will recharge as much as 78 million gallons of water to the underlying Westside Groundwater Basin each year (City of South San Francisco California, 2021). This groundwater recharge, a beneficial water management practice, can address overuse of groundwater, which can cause dry wells, sinking land, and saltwater intrusion from the ocean (Furtell & Liu, 2022).

Table 14: Summary of values used to calculate socioeconomic benefits for Orange Memorial Park.

Parameter	Orange Memorial Park
Type of Project	Regional underground stormwater capture system (**retention** basin) with recreational facilities and **infiltration** in design
Acreage	23.8 acres with 15 acres of green space
Population within 0.5 mile	12,052
Population within 2 miles	63,448
Located in an Underserved Community per CalEnviroScreen vulnerability	Moderate - 37% highly vulnerable
Estimated Number of Trees	460

5. Results

For each of the four case studies, Ceto estimated the economic value of the relevant benefits within the scope outlined in Section 2. All socioeconomic benefits applied to Earvin "Magic" Johnson Park in Los Angeles and Orange Memorial Park in South San Francisco. However, benefits related to use of urban green space were not applicable to the San Mateo Sustainable Streets Master Plan, nor was wetland creation or enhancement. Wetland creation was also not applicable to the Fresno Flood Control District's recreation retention basins.

Table 15: Matrix showing which socioeconomic benefits pertain to which project case study.

Benefit	Earvin "Magic" Johnson Park	San Mateo Sustainable Streets Master Plan	Fresno Metropolitan Flood Control District Recreation Basins	Orange Memorial Park
Urban Green Space: Creation of public space	✓	Reduced Impact	✓	✓
Recreation: Enhanced recreational opportunity	✓		✓	✓
Water Quality: Improved or enhanced	✓	✓	✓	✓
Community Health: Improved community health	✓	Water Quality and Air Quality	✓	✓
Wetland Creation: Restoration or protection of wetlands	✓			✓

5.1 Annual Economic Value Generated

The benefit transfer method was applied to relevant socioeconomic benefits for each of the four case studies to estimate an annual non-market value for each project. The larger scale, jurisdiction-wide projects (Fresno and San Mateo) generated the highest cumulative annual non-market value, while the individual park projects (Earvin "Magic" Johnson and Orange Memorial) generate considerably higher per-project benefits. As shown in Table 16 below, the 22 regional retention basins that the Fresno Metropolitan Flood Control District has integrated with green space and recreation generate the highest total economic value of benefits, at over $250 million annually. The 41 projects throughout San Mateo County combined generate over $130 million in socioeconomic benefits. The stand-alone stormwater capture parks, Earvin "Magic" Johnson and Orange Memorial, generate $88 million and $47 million in co-benefits annually, respectively. Looking at the socioeconomic benefits Earvin "Magic" Johnson and Orange Memorial parks, they far exceed the socioeconomic benefits of each of the San Mateo or Fresno projects, which generate an average of $3.2 million and $12.1 million per project site, respectively. The assessment results are presented in Table 16 below.

Table 16: Estimated socioeconomic benefit value for selected stormwater capture projects in California.

Benefit	Benefit Considerations	Earvin "Magic" Johnson Park	San Mateo Sustainable Streets Master Plan	Fresno Converted Basins	Orange Memorial Park
Community Health	Mental Health: ADHD, medical costs, life satisfaction	$4,910,900	N/A	$23,800,000	$2,706,400
	Physical Health: Avoided medical costs, physical activity, Alzheimer's disease	$28,777,500	N/A	$139,400,000	$15,860,000
	Urban Heat Island: Avoided medical costs, avoided ER costs, prevented loss of life	$311,400	$348,800	$1,170,000	$477,500
	Air Quality	$582	$652	$2,200	$892
Water Quality	Improved Quality or "Good" Quality Maintained	$31,479,900	$108,582,000	$82,600,000	$9,850,000
Green Space	Increase in Property Values within 100m	$9,424,000	$24,732,800	$20,120,000	$16,496,000
Wetlands	Ecosystem Services Provided by Urban Wetlands	$12,854,400	N/A	N/A	$1,589,000
Recreation Parks	Value of Recreation to Community within 0.5-mile	$21,600	N/A	$79,100	$11,900
TOTAL ANNUAL VALUE		$87,780,000	$133,664,000	$267,171,000	$46,992,000
TOTAL ANNUAL VALUE PER PROJECT		$87,780,000	$3,260,000	$12,144,000	$46,992,000

It is important to note that almost all of the socioeconomic benefits generated by the San Mateo Sustainable Streets Master Plan projects derive from enhanced water quality, especially due to the geographic extent of their projects and the number of residents falling within two miles of a project site. Improved water quality accounts for 81% of the total socioeconomic benefits of the 41 projects, with only $25 million in other benefits. Furthermore, $24.7 of the $25 million in estimated socioeconomic benefits result from increased property values resulting from enhanced community aesthetics. The 41 projects, therefore, results in only a combined $0.35 million in community benefits to health or quality of life beyond water quality. The survey results (see Section 2) suggest that Region 2 prioritizes water quality and public safety, and the San Mateo Sustainable Streets Master Plan design reflects these priorities and generates significant benefits. Survey responses, however, also suggest managers in Region 2 place high importance on enhanced community health, while this capture methodology contributes little in health-related benefits aside from potential reductions in UHI.

This analysis examined only 22 of the Fresno Metropolitan Flood Control District's 150+ regional retention basins, as only those 22 were also parks and were therefore expected to generate any valuable socioeconomic benefits. Based on the information available to Ceto, the remaining retention basins do not include any green infrastructure features that would be expected to generate socioeconomic benefits besides water quality improvements. By including urban green space with usable recreation areas in the 22 existing retention basins, the Fresno Metropolitan Flood Control District created an additional $250 million in benefits annually, with the largest share of these benefits stemming from improvements to community health. This is especially significant as 61% of these parks immediate service area (0.5-mile buffer) scores within the highest vulnerability range according to the CalEnviroScreen, indicating the community is significantly exposed to the effects of environmental degradation (see Section 5). According to the survey of CASQA members (see Section 2), Region 5 managers place a moderate level of importance on enhanced recreation and community health. This analysis shows that the outcome of prioritizing these considerations can be significant. Converting the retention basins to public parks generates an average annual value of over $12.1 million per park, indicating a high benefit/cost ratio for the investment.

5.2 Environmental Justice and Vulnerability

Alongside the economic and environmental indicators outlined above, it is necessary to consider the disproportionate impact that climate change and climate-related disasters have, and will have, on low income and marginalized populations. The aforementioned impact is not typically considered in infrastructure planning and feasibility analysis; however, this is an oversight that may further reinforce structural inequalities.

Low-income and marginalized communities already face degraded environmental conditions, such as poor air quality, higher temperatures, and flooding (Islam & Winkel, 2017; McHale et al., 2019; Zeise et al., 2013; Zhang et al., 2021). The unequal burden climate change places on low-income communities and communities of color has been referred to as the "climate gap" and refers to both the immediate impacts of climate change (e.g., heat, air quality, flooding) and the secondary impacts (e.g., cost of living, opportunities, wages) (Morello-Frosch & Obasogie, 2023; Morello-Frosch et al., 2009).

The impacts of environmental justice inequality have been recognized recently by federal agencies. A 2023 report by the U.S. Department of Treasury provided estimates of household level economic impacts due to climate change. These impacts vary from lost wages to higher prices to reduced transportation availability, and have the greatest impact on marginalized households, especially those in at-risk areas and industries (U.S. Department of the Treasury, 2023). The 2018 National Climate Assessment (NCA) found that, "low-income communities already have higher rates of many health conditions, are more exposed to environmental hazards and take longer to bounce back from natural disasters," and the most recent NCA (NCA5, published in 2023) only strengthened this finding (Hayden et al., 2023; USGCRP, 2017).

Although these reports clarify the effects of the climate gap, there is no consensus on the associated monetary costs. Environmental inequality and the disproportionate burden of climate change affect every aspect of an individual's economic wellbeing, including their access to credit, their access to property, their earning potential, and their healthcare costs (Morello-Frosch et al., 2009; U.S. Department of the Treasury, 2023). Research on environmental justice emphasizes that climate change and existing environmental inequality have a significant impact on *human health*. Specifically, poor air quality has been linked to 40% greater incidences of childhood asthma, and heat-related health impacts have been linked to 59% higher likelihood of heat-related mortality (EPA, 2021).

Part of the reason low-income communities and communities of color face such adverse impacts are due to their built environment. In urban areas, these communities typically lack green space, tree cover, and access to safe outdoor spaces and recreational opportunities.

Urban stormwater capture projects can have an impact on existing environmental inequality and the future impacts of climate change by helping to improve environmental conditions in disadvantaged and low-income areas. Of the socioeconomic benefits assessed in this report, those most relevant to the discourse around the climate gap are: (1) community health and (2) recreation. Projects that provide urban green space will impact air quality, mental and physical health, UHI impacts, and recreation.

To account for the climate gap, the economic value of these benefits was adjusted in proportion to the research on exposure and adverse impacts to low-income communities and communities of color. This adjustment employed a geospatial analysis of: (1) local demographics and climate vulnerability using CalEnviroScreen 4.0, and (2) the availability of alternative urban green space nearby. Combining these two data points, an impact factor was constructed to capture the expected increased value of socioeconomic benefits in communities facing significant disadvantage. This impact factor was then applied to the estimated health and recreational benefits for each project, as the data sources determine vulnerability in terms of health impacts and lack of usable green spaces.

CalEnviroScreen 4.0 is an advanced assessment tool created by the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) for use specifically in California to evaluate the cumulative effects of pollution on local communities. The tool addresses the limitations of traditional risk assessments by integrating 21 indicators across four key components: Exposures, Environmental Effects, Sensitive Populations, and Socioeconomic Factors. These indicators include a range of factors including, but not limited to pollutant sources, air and water quality standards, toxic cleanup sites, and other demographic measures like asthma incidence rate, poverty level, education status. By utilizing a percentile-based scoring system, CalEnviroScreen 4.0 provides a relative evaluation of pollution burdens and vulnerabilities. Thus, it offers a comprehensive perspective on the environmental and health risks faced by different communities across California.[8]

[8] CalEnviroScreen 4.0's methodology involves averaging percentiles for individual indicators within each component, resulting in Pollution Burden and Population Characteristics scores. These scores are then scaled and combined to produce an overall ***CalEnviroScreen*** score for each census tract, which serves as a measure of vulnerability. With a maximum score of 100, the percentile ranking of a specific area indicates the percentage of all ordered CalEnviroScreen scores that fall below that area's score. This relative scoring system allows for the

The tool's percentile-based scoring system allows for the categorization of areas into distinct groups based on their relative environmental burdens and vulnerabilities. Typically, percentile ranges are used to create these groups, with higher percentiles indicating more significant environmental burdens and greater vulnerability. In this assessment, we grouped the percentiles into quartiles:

- Low Impact/Vulnerability 0-25th percentile
- Moderate Impact/Vulnerability: 26-50th percentile
- High Impact/Vulnerability: 51-75th percentile
- Very High Impact/Vulnerability: 76-100th percentile

Geospatial analysis of environmental vulnerability, as quantified by CalEnviroScreen, for each of the four case studies is presented in Figure 11 through Figure 14 below.

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identification of communities with the highest cumulative environmental burdens and vulnerabilities, providing valuable insights for targeted resource allocation and environmental justice initiatives.

Going beyond traditional risk assessments, CalEnviroScreen 4.0 considers the totality of factors influencing a community's exposure to environmental pollutants. By integrating pollution burden with population characteristics, including the identification of sensitive populations and socioeconomic factors, the tool enables a nuanced understanding of environmental justice issues.

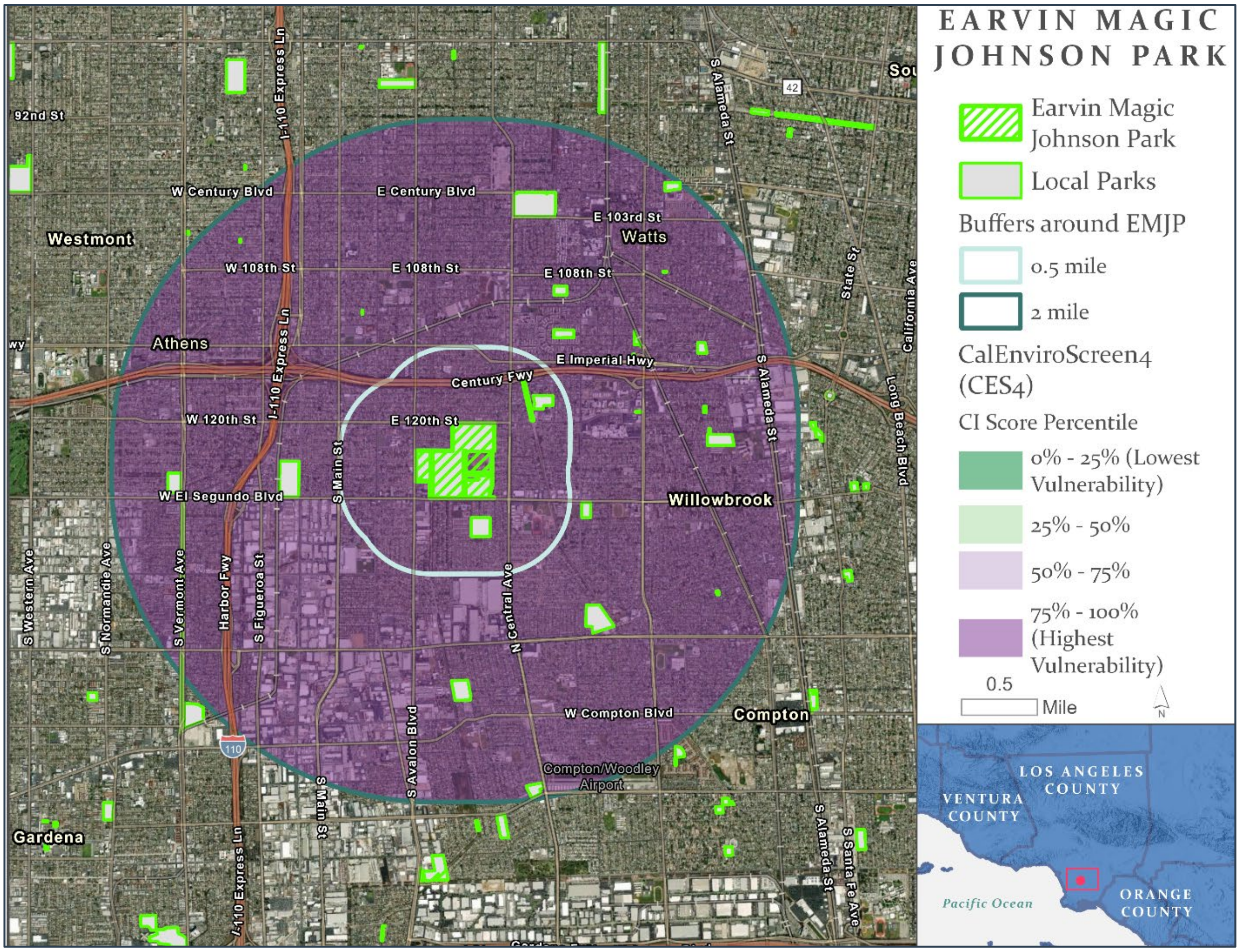

Figure 11: Earvin "Magic" Johnson Park is shown in the middle of the figure. Within both the immediate 0.5-mile buffer (light blue) and the larger 2-mile buffer, 100% of the area falls within the quartile for highest environmental vulnerability according to CalEnviroScreen. Furthermore, there are no parks of comparable size or amenities within the buffers. Without taking into consideration the environmental vulnerability and alternate greenspace, Earvin "Magic" Johnson Park generates significant co-benefits due to the community health, recreation, water quality, and urban green space benefits it provides. However, considering the relative disadvantage of the community (as indicated by the CalEnviroScreen), the project generates far greater benefits especially for community health.

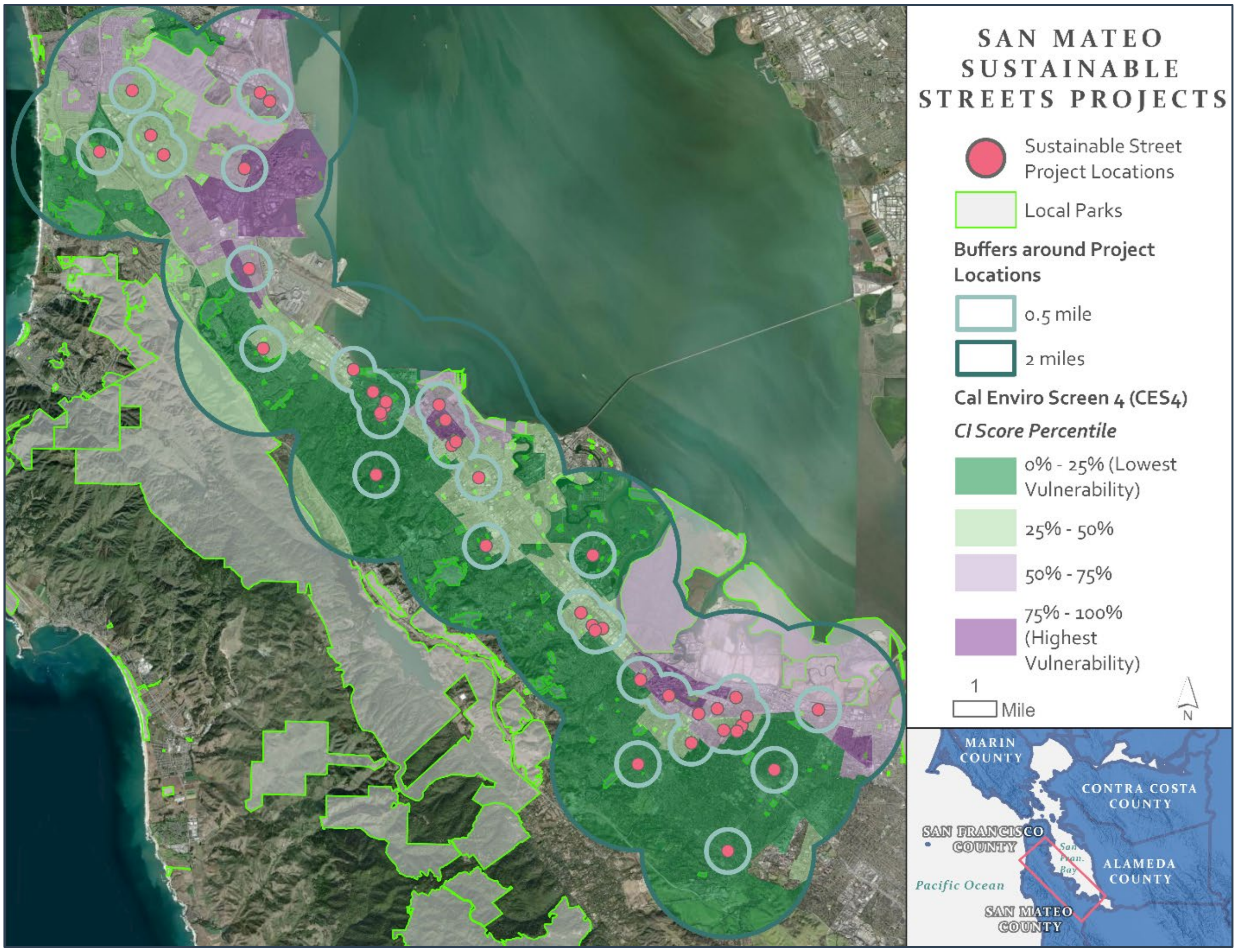

Figure 12: The above map shows all stormwater capture projects built throughout San Mateo County leading up to and after completion of the Sustainable Streets Master Plan, with each project indicated as a point. For the geospatial analysis to determine co-benefits, a 0.5-mile and 2-mile buffer were drawn around each project site. Most of the buffer falls within areas of lowest vulnerability from CalEnviroScreen, and there is significant additional urban green space in proximity. These factors, in addition to the fact that the San Mateo projects do not generate appreciable physical health or recreational benefits (aside from air quality and UHI reductions) within the context of this study, resulted in no adjustment for environmental inequity.

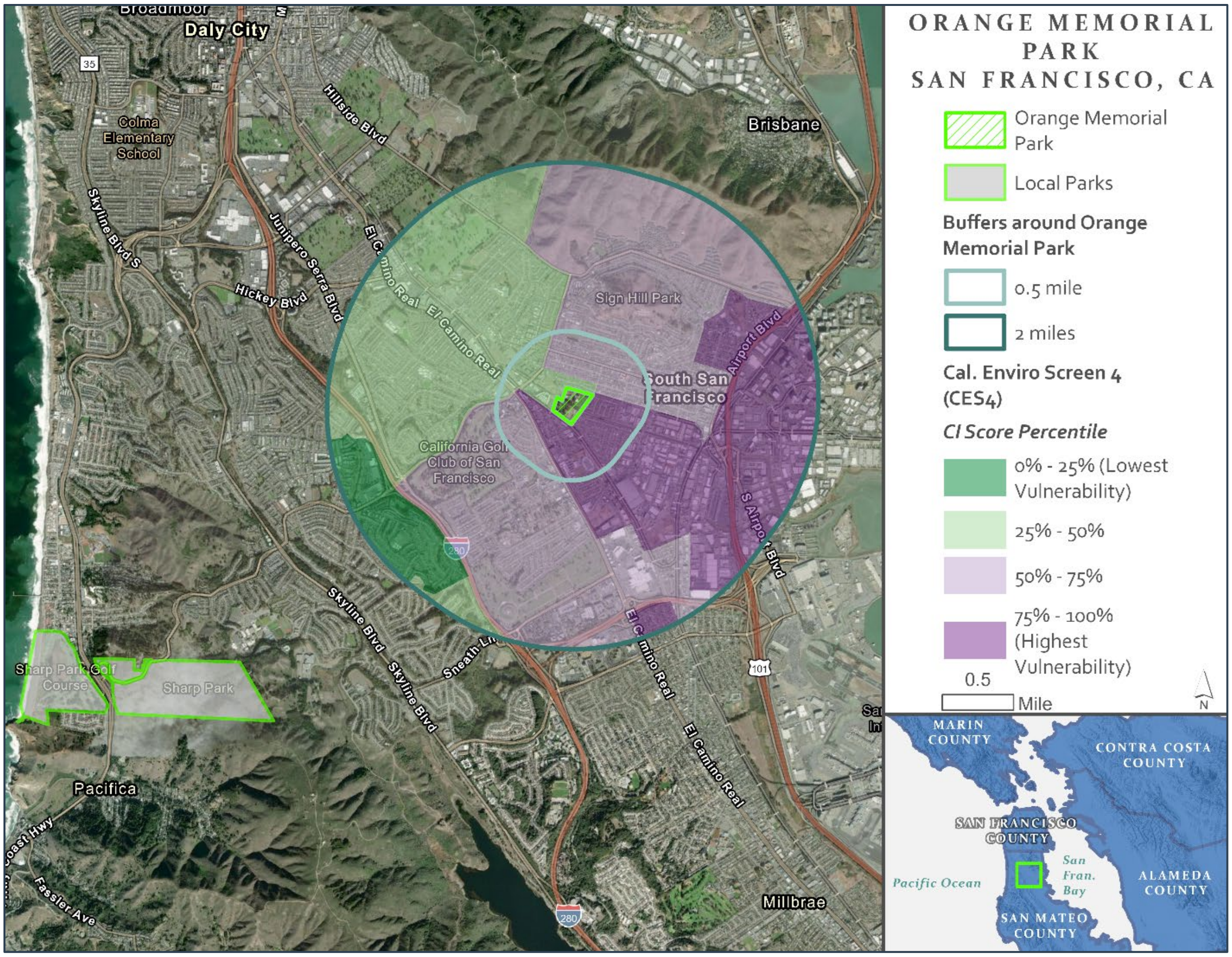

Figure 13: The above map shows the geospatial analysis that informed co-benefit calculation and vulnerability adjustments for Orange Memorial Park in South San Francisco. The surrounding area is moderately vulnerable, with 37% of the community falling within the “highest vulnerability” category on CalEnviroScreen. In addition, there are *no alternative urban green spaces* within proximity (neither 0.5-mile nor 2-mile radius), which creates a greater need for urban green space and the benefit it provides to the community, as there are no alternative sites. The adjustment for environmental inequality factors in the lack of alternate parkland in the assessment area.

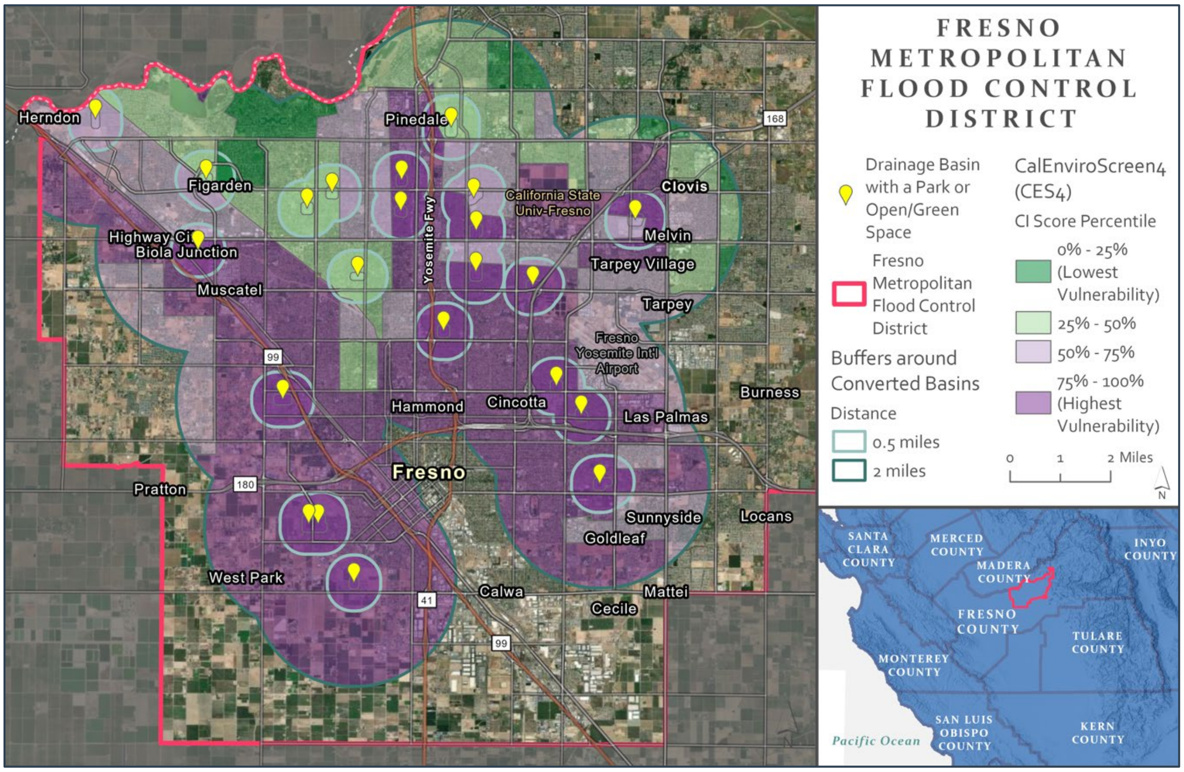

Figure 14: The above maps show the 22 stormwater retention basins that the Fresno Metropolitan Flood Control District has integrated with a park or green space (indicated by the 0.5-mile buffer around them). For this analysis, only these areas were evaluated for the socioeconomic benefits examined in this report. As the geospatial analysis shows, a significant portion (61%) of the area served by these parks falls withing "highest vulnerability."

By assigning census tracts to these percentile-based groups, we created a simplified representation of environmental impact levels across our case-study project areas. An impact factor was assigned to each group. This grouping approach provides an accessible way to communicate the relative environmental burdens and vulnerability faced by communities. Non-market values of health-related benefits were then adjusted based on the literature on the unequal burden of climate costs (Hayden et al., 2023; Morello-Frosch & Obasogie, 2023; Morello-Frosch et al., 2009; U.S. Department of the Treasury, 2023). An additional adjustment accounts for the lack of parkland and urban green space present in the communities surrounding Earvin "Magic" Johnson Park and Orange Memorial Park. The adjusted value of socioeconomic benefits for each project, accounting for environmental inequality, are presented in Table 17 below. To capture the expected value of the climate gap in these communities, the value of health and recreational benefits was adjusted by 30-80% depending on the relative vulnerability of each community. Table 17 shows the value of each urban stormwater capture project adjusted for community vulnerability, which most significantly alters the value for the Los Angeles and South San Francisco projects.

Table 17: The nonmarket value of socioeconomic benefits considering environmental vulnerability.

Economic Value ($ 2023)	Earvin "Magic" Johnson Park	San Mateo Sustainable Streets Master Plan	Fresno Recreation Basins	Orange Memorial Park
Total Annual Value	$114,997,800	$133,664,500	$316,531,200	$56,517,500
Total Annual Value Per Project	$114,997,800	$3,260,100	$14,387,800	$56,517,500

6. Discussion

Building on the considerable examination of the benefits of stormwater capture to California and nationwide, this assessment offers a new perspective for the planning and implementation of urban stormwater capture projects. Preliminary findings from four case studies suggest that in a single year, urban stormwater capture projects generate socioeconomic benefits worth more than the project construction costs. In other words, the benefits of the projects offset the costs. Prior studies have largely focused on the benefits of stormwater capture to augment strained water supply and to reduce flooding. While those expected benefits are significant and easily quantifiable, there are additional project benefits that should be considered. Urban stormwater capture projects built with green infrastructure can have a significant positive impact on the community in which they are located. These benefits include not only the benefits of stormwater management (e.g., reduced flooding, property damage, and risks to public safety), but also a diverse range of socioeconomic benefits. These auxiliary benefits result from the incorporation of green infrastructure design elements into the overall project, rather than the quantity of stormwater captured. Thus, they exist independent of the amount of water captured by the project. This report aims to give explicit values to these benefits by examining four representative projects in California. Ceto found that these benefits ranged from $3 million to $87 million annually per project site, depending on the scale and design of the project.

It is important to understand the potential benefits of these projects holistically, in order to properly consider the costs and benefits of a proposed project. Often, the non-market benefits are left out of these considerations when they can meaningfully increase the cost/benefit ratio of a project. Without a dollar value for the auxiliary socioeconomic benefits, comparing the benefits and costs of the project is like comparing apples to oranges. Having explicit estimates for these additional benefits allows them to be properly factored into project planning and public discourse. Having an estimated value helps justify a project and focus the discussion on tangible public impacts. By considering the potential community benefit, urban stormwater capture projects can meaningfully improve quality of life for urban communities by providing valuable urban green space that can improve air and water quality, provide opportunities for recreation, benefit the physical and mental health of the community, augment critical wetland habitats, and increase the climate resilience of cities by reducing urban heat islands, among other benefits.

Of course, capital investment projects like urban stormwater capture must be in line with the needs and priorities of the communities in which they are proposed. For some communities, there may be sufficient green space already available to residents and a high level of environmental health. In these communities, the auxiliary benefits of a project will be less significant – a new park or green space would not meaningfully change the opportunities available to that community. In these areas, projects will see most of their benefits from reduced flooding and improvements to water quality and public safety. With those as priorities, community planners should opt for designs which maximize those benefits and may not incorporate significant urban green space-related benefits. In other areas, however, an urban green space project can make a significant difference in quality of life. Areas with poor environmental health, few options for urban recreation, and limited green space will see significant additional benefits from urban stormwater capture projects that create urban green spaces with amenities for recreation and health-promotion.

Understanding community needs and priorities, projects can still create additional benefits of significant value. The San Mateo Sustainable Streets Master Plan, for example, comprises 41 small-scale green streets projects. These projects are mostly small bioretention areas in stormwater curb extensions, medians, rain gardens, and similar green infrastructure features designed to improve San Mateo streets and facilitate improved stormwater capture. Of the socioeconomic benefits evaluated in this analysis, water quality improvements from these sustainable streets' projects generate the greatest non-market value, followed by increased home values. The projects create few of the additional health benefits evaluated and no recreational space. However, health improvements and additional recreational space are not of high need in the area; less than 10% of areas within 0.5 miles of a project fall within the CalEnviroScreen "high vulnerability" classification. In addition, there are more than 17,000 acres of parks in San Mateo County within 2 miles of the project sites, so the impact of adding one more park is proportionally not as significant as an urban area with fewer parks (e.g., the sites of Earvin "Magic" Johnson Park or Orange Memorial Park).

The four case studies not only reveal how urban stormwater capture projects can generate significant benefits to the communities in which they are located, but also how different project designs determine the extent of those benefits. If cities and water managers wish to create the greatest positive socioeconomic impact, they should focus on projects that create *usable* urban green space. This means opting for *projects that provide space and amenities for recreation and other health-supporting activities.* For example, an engineered stormwater park design, like that of Earvin "Magic" Johnson Park in Los Angeles, boasts significant benefits to community health and recreation by creating multiple areas for recreation and providing almost 50% of the parkland available to that community.

Finally, considerable community benefit can be generated by implementing urban green space and green infrastructure at existing sites, as demonstrated by the fact that the 22 retention basins in Fresno that have been designed with parks and green space generate over $250 million annually. As Figure 15 below shows, there are many more retention basins throughout the Fresno Metropolitan Flood Control District. There are also relatively few parks or green spaces available, especially closer to the city center. Given that the value to the community of a single recreation basin is significant (over $12.1 million annually), Fresno could generate considerate benefit by converting additional retention basins into usable urban green space. They could maximize this benefit by focusing these efforts in areas of high vulnerability with few alternative parks or urban green space sites.

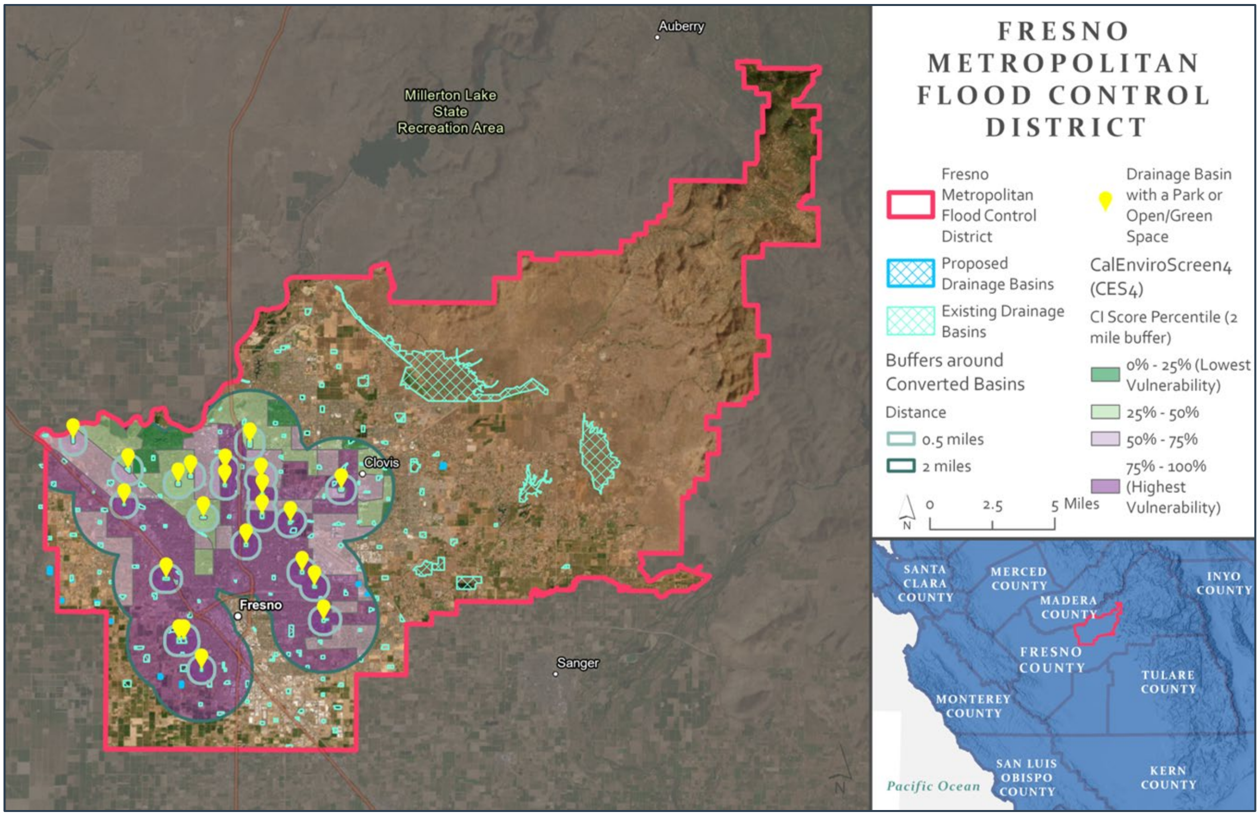

Figure 15: The above map shows the geospatial analysis of the 22 converted retention basins depicted in Figure 14 along with all other retention basins in the Fresno Metropolitan Flood Control District. This demonstrates high potential for continuing to generate non-market value via retention basins with a park or green space.

Additionally, the non-market value of the socioeconomic benefits of urban stormwater capture projects can be maximized by siting these projects in areas of highest need. Simply put, a project which creates urban green space in a high-need area will maximize benefits to the community. This study focused on the health and recreational disparities facing many urban communities and the expected impact of usable urban greenspace on health outcomes in those areas. Estimating these impacts shows the significant value of urban stormwater capture projects in these areas. To help mitigate the health-related effects of the climate gap, statewide funding for urban stormwater capture parks and larger-scale projects should focus on highly vulnerable areas with poor environmental health indicators and limited alternative green spaces or parks.

Key Recommendations:

- Design stormwater capture projects to maximize the most important benefits for a given community.
- To maximize recreational and health benefits of projects generating urban green space, site projects in communities with high environmental and socioeconomic vulnerability and few alternative public green spaces.
- Consider converting existing retention areas into functional urban green space (with recreation) to incorporate these benefits and maximize the total benefits of stormwater capture projects.

It is not possible to estimate the total value of socioeconomic benefits for large-scale adaptation and implementation of urban stormwater capture statewide. The value of socioeconomic benefits is based on the specifics of each project design and location rather than a fixed estimate for any given project design, or an estimate based on acre-feet of water captured. Furthermore, project design should depend on each community's needs and priorities, which means projects are not readily transferable across the state. However, the four case studies described herein offer an indication of the scale of possible socioeconomic benefits and the high value of these benefits in comparison to project costs. As shown in Table 18, the value of annual socioeconomic benefits offset project cost for all the case studies examined in this report. Crucially, this value is *in addition to the* benefits of these projects to water supply, public safety, and property protection.

Table 18: Project costs and non-market value of socioeconomic benefits.

Project	Cost Per Project	Non-Market Value of Socioeconomic Benefits (annually)	Benefit/Cost Ratio
Earvin "Magic" Johnson	$83 Million[9]	$88 Million	1.06
San Mateo Sustainable Streets - Average Project	$1.5 Million[10]	$3.2 Million	2.13
Orange Memorial Park	$27.4 Million[11]	$47.0 Million	1.72
Fresno Recreation Retention Basins – Average Project	$5.8 Million[12]	$12.1 Million	2.09

6.1 Considerations

This report provides proof of concept for the significant value of socioeconomic and environmental benefits of urban stormwater capture to communities. While this report provides a consistent methodology for evaluating the socioeconomic benefits of urban stormwater capture projects in California, this work is best done on a project-by-project basis, where values can be tailored to the local needs and community-level data.

- For future stormwater capture projects, Ceto recommends refining the methodology outlined in this report with local data, including using local demographic/socioeconomic data as well as any

[9] Cost from Griffith Company (2020), adjusted to 2023 dollars. https://griffithcompany.net/portfolio/earvin-magic-johnson-park-phase-1a/#:~:text=At%20a%20cost%20of%20roughly,Los%20Angeles%20County%20Park%20system

[10] Cost from Flows to Bay, Lotus Water Engineering, Urban Rain Design (2021), Appendix E – Conceptual Designs for Sustainable Streets Priority Projects adjusted to 2023 dollars. https://www.flowstobay.org/wp-content/uploads/2021/02/Appendix-E-SSMP-Priority-Projects-Concept-Designs_final-1.pdf and additional costs provided by the City of San Mateo.

[11] Cost from the City/County Association of Governments of San Mateo County presentation of conceptual design for Orange Memorial Park (2016) adjusted to 2023 dollars, prepared by Paradigm Environmental (https://ccag.ca.gov/wp-content/uploads/2017/01/CCAG_SWRP_concepts_6-15-16.pdf)

[12] Cost from the Fresno Metropolitan Flood Control District accounting for engineering, acquisition, and construction costs for the 21 projects. Amounts reflect the *average cost per project, adjusted to 2023 dollars.*

information available on the expected uses of urban green space to estimate the recreational benefits and community health benefits associated with urban green space use.

- Using existing climate models to estimate urban heat island related impacts for the future, focusing on the specific impacts of tree and vegetation planting on localized reductions in extreme temperatures and how that will reduce expected excess deaths (mortality) and hospitalizations (morbidity).
- Using watershed or water management maps to determine the radius of California residents who would benefit from water quality enhancements or preservation. This analysis uses a *very* conservative 2-mile radius, but other studies have ranged as far as 100 miles.

The methodology from this report, supplemented with local data, could be incorporated into the planning stages of urban stormwater capture projects to demonstrate the significant value they can have to communities in California.

6.2 Public Benefit

Capital investment decisions are made in large part at the local level. Understanding the local benefits of a project in explicit terms can help justify these decisions to the public that will benefit most from them. This report examines a very narrow radius around these projects – a buffer of 100 meters, 0.5 miles or 2 miles – and the expected benefits to the residents in those immediate impact areas. The socioeconomic benefits of these projects, in that small area alone and for a single year, are sufficient to offset the costs of these projects. Furthermore, while numbers are helpful for justifying investment, focusing on the community benefits of these projects allows residents to see the projects as an improvement to their quality of life. The socioeconomic benefits discussed in this report are not abstract concepts, but real, tangible effects on people's environments. Offering more green space in urban areas, creating recreational opportunities, and in turn improving people's physical and mental health are all impacts the public can see and appreciate immediately. Understanding these benefits does not require understanding future climate scenarios or understanding complex concepts. While discourse surrounding infrastructure projects often overemphasizes the cost component, valuing these public benefits helps the public weigh the costs of the project against improvements they will receive year after year, irrespective of the volume of water captured by the constructed project.

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